

Drift Cards on Puget Sound and Juan de Fuca Strait in the years 2000-2001

Kari A. Sauers and C. Ebbesmeyer
Evans-Hamilton, Inc.

Bruce Nairn and Mickelson
King County Department of Natural Resources

Introduction

King County has proposed building a new sewage treatment plant with an outfall in northern Puget Sound, Washington. With the addition of this outfall, there is a requirement to resolve the currents in the Triple Junction region (where Admiralty Inlet, Possession Sound and Main Basin join), in particular, to understand the mechanisms involved in the dispersal of anthropogenic material.

The circulation of Puget Sound is characteristic of fjords, in which the currents are primarily driven by tides and winds, and fresh water flowing seaward and saline bottom water flowing landward (Lavelle and others 1991). Puget Sound's largest runoff flows from the Skagit River, discharging at the northern end of Possession Sound. The winds are predominantly from the south during winter storms, which reinforces the Main Basin's outflowing surface water, and from the north during periods of good weather, which impedes and sometimes reverses the surface flow (Matsuura and Cannon 1997; Cannon 2000b).

Until recently, few studies have examined the circulation patterns in the Triple Junction. A variety of current meters are commonly used for this purpose. Practical constraints, however, limit these instruments from measuring shallower than a few meters depth.

Hydraulic model studies have shown that an estimated ten percent of the total effluent solids from an outfall diffuser rise to the surface in the form of oils and greases, making it important to understand the surface circulation patterns (Word and others 1990). Sewage effluent materials such as oils and greases, bacteria and viruses, and heavy metals concentrate in the upper few centimeters of the sea surface known as the microlayer, which collects and disperses floatable materials. Drift cards offer one of the few practical alternatives, as they reflect the advection and dispersion in the surface layer, and have proven to be an effective tool for the determination of near-surface flow.

During the last 50 years, a number of drift studies have been carried out in the Pacific Northwest, including 50,000 drift cards released (Ebbesmeyer and Coomes 1993; Ebbesmeyer and others 1995; Ebbesmeyer and others 1998a; Ebbesmeyer and others 1998b). Puget Sound beachcombers typically report approximately 50% of the cards released. In the present study, 1200 drift cards were set adrift under various combinations of tides and winds.

Methods

Drift cards as well as drogues were released in the Triple Junction, as described below.

Drift Cards

To provide information on how surface mixing varies with distance from shore, drift card release sites were located along transects positioned through the study area ([Fig. 1](#)): sites 1 and 2 to determine surface current dispersal in Possession Sound; sites 3 and 4 off Browns Bay to determine dispersal in the Triple Junction; sites 5 and 6 off Point Wells to determine distribution immediately south of the Triple Junction; and sites 7 and 8 off Carkeek Park to determine effects of surface currents south of the current bifurcation in the eddy north of Meadow Point. Inshore sites 2, 4, 6 and 8 were located above the 70-meter isobath, and sites 1, 3, 5 and 7 were positioned approximately 1 mile offshore from the respective 70-meter depth sites.

Puget Sound Research 2001

The drift cards were cut from thin pieces of plywood measuring approximately 3x5 inches, and coated with orange, non-toxic paint to make them environmentally friendly yet readily visible to beachcombers. A serial number on each card indicated release date and location. Street and e-mail addresses, an 800-telephone number and instructions as to the information required enabled beachcombers to easily report recoveries ([Fig. 2](#)).

Using a Global Positioning System (GPS), each deployment consisted of 50 cards released from each site, beginning with Site 1 and proceeding sequentially through Site 8, totaling 400 cards. The cards were released under various combinations of wind and tide conditions (August 28, October 25, November 30, 2000). The first release took place during an ebb tide between 0730 and 0930 (Pacific Standard Time) under weak and variable wind conditions. The second release was during the last half of an ebb tide, through slack tide, and into the first part of the following flood tide. This occurred between 0920 and 1030, under weak and variable winds. The third release occurred during a weak ebb tide between 1000 and 1200, with an average wind speed of approximately 12 knots from the south.

To quantify the drift card recoveries, the shoreline of the Strait of Juan de Fuca and Puget Sound were segmented into half-mile [intervals](#) and the region was separated into three recovery zones: Puget Sound, Admiralty Inlet and the Strait of Juan de Fuca. Definitions of the areas are shown in [Figure 2](#) and described in [Figure 5](#).

Because drift cards provide data on the release and recovery points, drogues were used to fill in the intervening times.

Drogues

Drogues were deployed on August 28 and October 25, 2000, concurrent with the cards released at each drift card site. The August 28 drogues consisted of the blue barrel in the upper meter of water without the skirt, and on October 25 the drogue skirt was positioned between 20 and 30 meters.

The combined release of a drogue and 50 drift cards assisted in understanding where currents transported the drift cards before beaching. It also helped assess if the drift card results were characteristic of the shallowest meter of water, or if they are more representative of the surface microlayer.

For comparison with the drift card and drogue results, net flow patterns were ascertained from historical data, recently acquired ADCP data and results from a Puget Sound model.

Results

Drift Cards

Despite the proximity of the release sites, recoveries varied substantially. [Figure 2](#) shows all returns reported within two months after release. Overall, beachcombers reported 47% of the cards released (564 cards out of 1200 released), with 45.3% from the August 28 release, 46.5 % from the October 25 release, and 49.3% from the November 30 release. Nearly all the cards reported were found north of Point Wells, with only 10% (55) reported south of this location (none of which were found south of Alki Beach).

The majority of the cards from each release were reported within the first two weeks after deployment. At the end of the first two weeks, approximately 67% of the total number of cards reported had been recovered from the August 28 release, 57 % from the October 25 release, and 88% from the November 30 release ([Fig. 3](#)). Additionally, the percent returns are subdivided by site number and release date ([Fig. 4](#)).

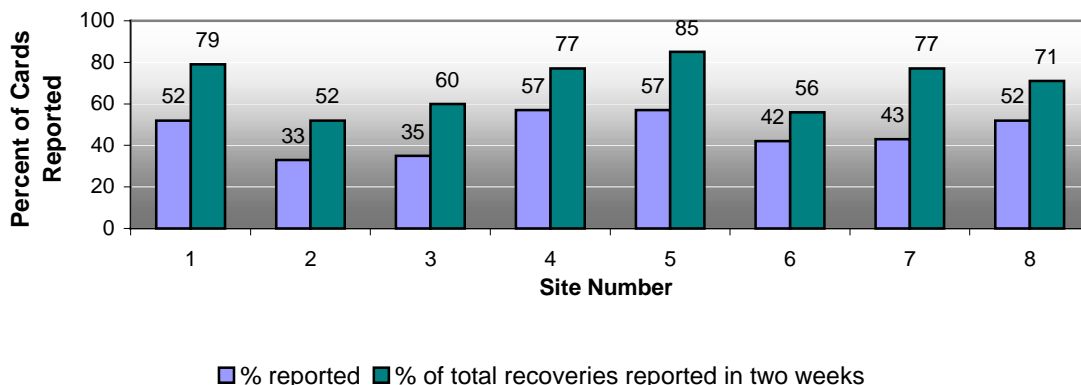


Figure 3 Summary for all releases of total percent returns and percent of cards reported within the first two weeks after deployment. See Fig. 2 for site locations. For example, at Site 1 in Possession Sound, 52% of all cards released (150) were reported with 79% of all those reported coming within two weeks after release.

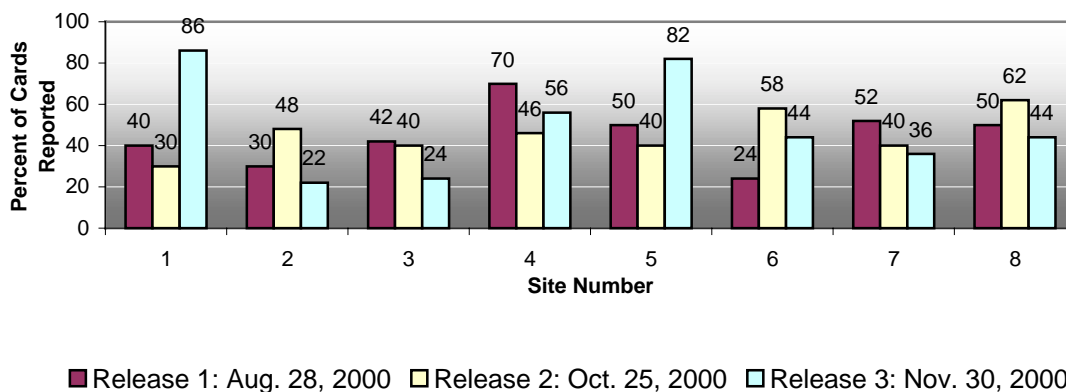


Figure 4 Summary of total percent returns for each release site and date (e.g., for Site 1 and Release 1 (August 28, 2000), 40% = 20 cards reported out of 50 cards released, multiplied by 100).

To examine the data more closely, the recoveries are shown in several ways, including: 1) all recoveries for all release dates ([Fig. 2](#)); 2) recoveries by release date ([Figs. 6-8](#)) and site ([Figs. 10-17](#)); and 3) origins of cards arriving at selected shorelines, including Indianola ([Fig. 18](#)), Point Edwards area ([Fig. 19](#)), Point No Point ([Fig. 20](#)), Double Bluff ([Fig. 21](#)), Admiralty Head ([Fig. 22](#)), and Dungeness Spit ([Fig. 23](#)). These figures are described below.

Recoveries in Main Basin, Admiralty Inlet, Juan de Fuca Strait ([Fig. 2](#))

Overall, beachcombers reported 47% (564 cards) of the 1,200 total cards released during August, October and November 2000. Of the total recoveries, 22% (123 cards) were found in Puget Sound, 61% (344 cards) in Admiralty Inlet, and 15% (86 cards) in Juan de Fuca Strait (2% were reported with out location). Definitions of these areas are described in [Figure 5](#). These percentages, however, varied substantially with the date of the drift card release.

Puget Sound Research 2001

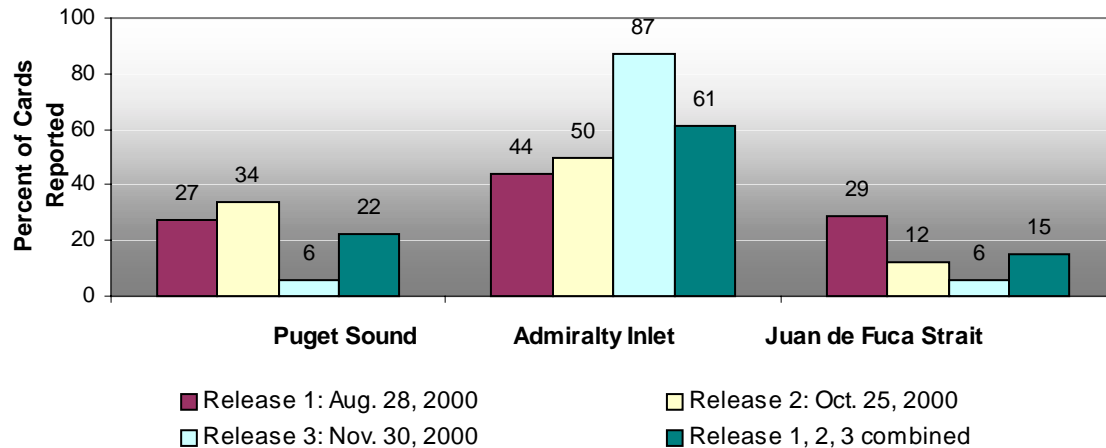


Figure 5 Summary of drift card releases during August, October and November 2000. Area definitions: Puget Sound, inland of latitude 47°56'N; Admiralty Inlet, between 47°56'N on the south and the line connecting Point Partridge and McCurdy Point on the north and; Juan de Fuca Strait, seaward of the northern boundary of Admiralty Inlet.

Recoveries By Release Date ([Figs. 6-8](#))

As the wind and tidal conditions differed between the release dates, the respective apportionment of the recoveries varied between the three general regions.

On August 28, the cards were released during a strong ebb tide under weak and variable winds ([Fig. 6](#)). This tide/wind combination dispatched most (73%, or 132 cards of the 181 reported) of the cards beyond the Triple Junction. A notable exception was the accumulation in the vicinity of Edwards Point primarily from releases at sites 3 and 4 (described in detail later). Two of the farthest recovery locations were from this deployment. Cards from sites 7 and 2 were found on the outer coast of Washington on Rialto Beach approximately one and a half months after release, and on Graham Island in the Queen Charlottes approximately four months after release, respectively.

On October 25, the cards were released toward the end of a strong ebb tide under weak and variable winds ([Fig. 7](#)). These conditions resulted in only 58% (108 cards of 186 found) beyond the Triple Junction. A notable exception was the number of cards that accumulated on the shores of Meadow Point, Double Bluff Beach and Mutiny Bay, and the accumulation of cards in the vicinity of Indianola, a feature not exhibited by the other deployments.

On November 30, the cards were again released on an ebb tide, this time during a smaller range accompanied by strong southerly winds ([Fig. 8](#)). The southerlies quickly scooted the cards out of the Triple Junction with the exception of one at the southern end of Whidbey Island. Most of the recoveries came from Double Bluff, Mutiny Bay and Admiralty Head, two prominent points of land in Admiralty Inlet.

It was also of interest to examine by date the differences between the inshore and offshore release sites. This comparison is shown in [Figure 9](#) below.

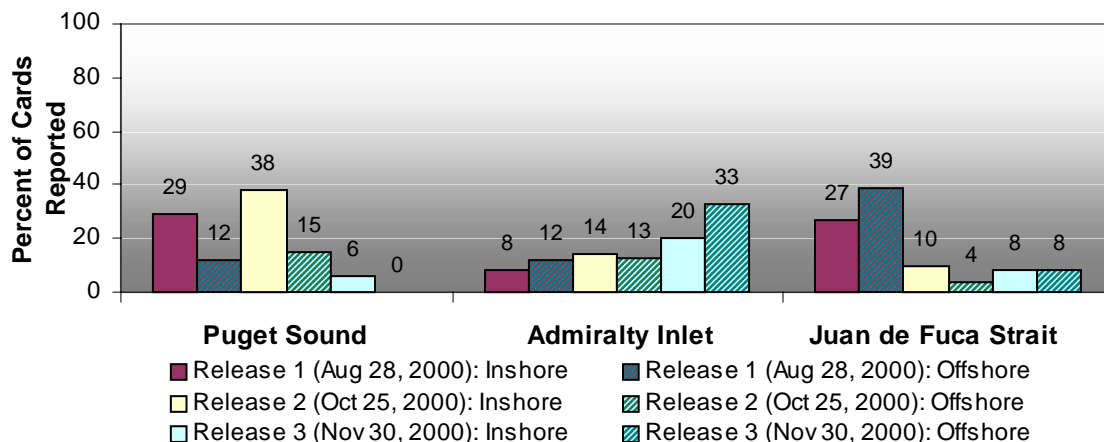


Figure 9 Comparison between inshore and offshore recovery results in each designated recovery zone. Note that in Puget Sound most card reports come from the inshore sites.

Some additional spatial aspects of the recoveries are given below.

Recoveries According To Release Site ([Figs. 10-17](#))

Sites in Possession Sound ([Figs. 10, 11](#)): Site 1 (~1 mile offshore from Site 2) and Site 2 (~70-meter depth). A few cards were found near Point No Point and at the southern tip of Whidbey Island. The remaining cards were recovered north of the Triple Junction in Admiralty Inlet and Juan de Fuca Strait.

Sites off Browns Bay ([Figs. 12, 13](#)): Site 3 (~1 mile offshore from Site 4) and Site 4 (~70-meter depth). Cards beached from these two sites showed similar behavior in that both had a relatively high number of cards reported on nearby shores (10 cards from Site 3 and 25 from Site 4), while the remaining cards were recovered north of the Triple Junction in Admiralty Inlet and Juan de Fuca Strait. In contrast to Site 3, which showed a more even distribution of recovery sites, cards from Site 4 seemed to concentrate along the shores of Admiralty Head and Marrowstone Island.

Sites off Point Wells ([Figs. 14, 15](#)): Site 5 (~1-mile offshore of Site 6) and Site 6 (~70-meter depth). Cards from these two sites exhibited much of the same recovery patterns, with the exception that Site 5 showed a much higher percentage of recoveries (37%, or 55 cards) in the region of Double Bluff. Few cards were recovered in the Triple Junction; several were found near Point No Point, and one card reported in Port Orchard is considered erroneous. A notable exception was that 83% of the recoveries from Indianola were from these sites, $\frac{3}{4}$ of which were from Site 6. The remaining cards were recovered north of the Triple Junction in Admiralty Inlet and Juan de Fuca Strait.

Sites off Carkeek Park ([Figs. 16, 17](#)): Site 7 (1-mile offshore of Site 8) and Site 8 (~70-meter depth). Cards from these two sites exhibited much the same recovery patterns as sites 5 and 6, except that Site 8 showed the higher percentage of recoveries (15%, or 22 cards). However, a number of cards traveled south and were recovered near Meadow Point and West Point. Some other cards traveled north to the vicinity of Point Wells.

Origins of Cards Arriving on Selected Shorelines ([Figs. 18-23](#))

Indianola ([Fig. 18](#)). Recoveries from this site were exclusive to the second deployment. The cards came from sites 4 through 7, but the majority originated from sites 5 and 6. Just under half of the cards were found within the first two weeks after the release, and the majority of the remaining cards were found over two months after the release.

Puget Sound Research 2001

Point Edwards area (Fig. 19). All but one card originated at sites 3 and 4 with most coming from Site 4 nearest to the shore. The only exception was a card launched off Carkeek Park. In terms of percentages, of the 300 cards released at sites 3 and 4 immediately off Point Edwards, about 12% (35 out of 300 released) were reported on the adjacent shoreline.

Point No Point (Fig. 20). Recoveries at this location were primarily from the first deployment, with only one card recovered from the second deployment.

Double Bluff (Fig. 21). Cards were recovered at this location from both Releases 2 and 3, but results from Deployment 3 emphasized this region as a favored collection zone for floatable materials.

Admiralty Head (Fig. 22). Cards from all but one release site (off Point Wells) arrived at this shoreline segment. By far, most of the arrivals originated from Site 4 nearest to shore immediately north of Point Edwards. Interestingly, this is also the site that supplied most of the cards to the vicinity of Point Edwards.

Dungeness Spit (Fig. 23). The 26 total cards that made it out of Puget Sound to Dungeness Spit amount to about 6% of the total recoveries.

The relationship of recoveries versus distance was also examined (specifically, the percent of total cards reported within an area and the distance to that area from the site that provided the highest percent of cards) (Fig. 24).

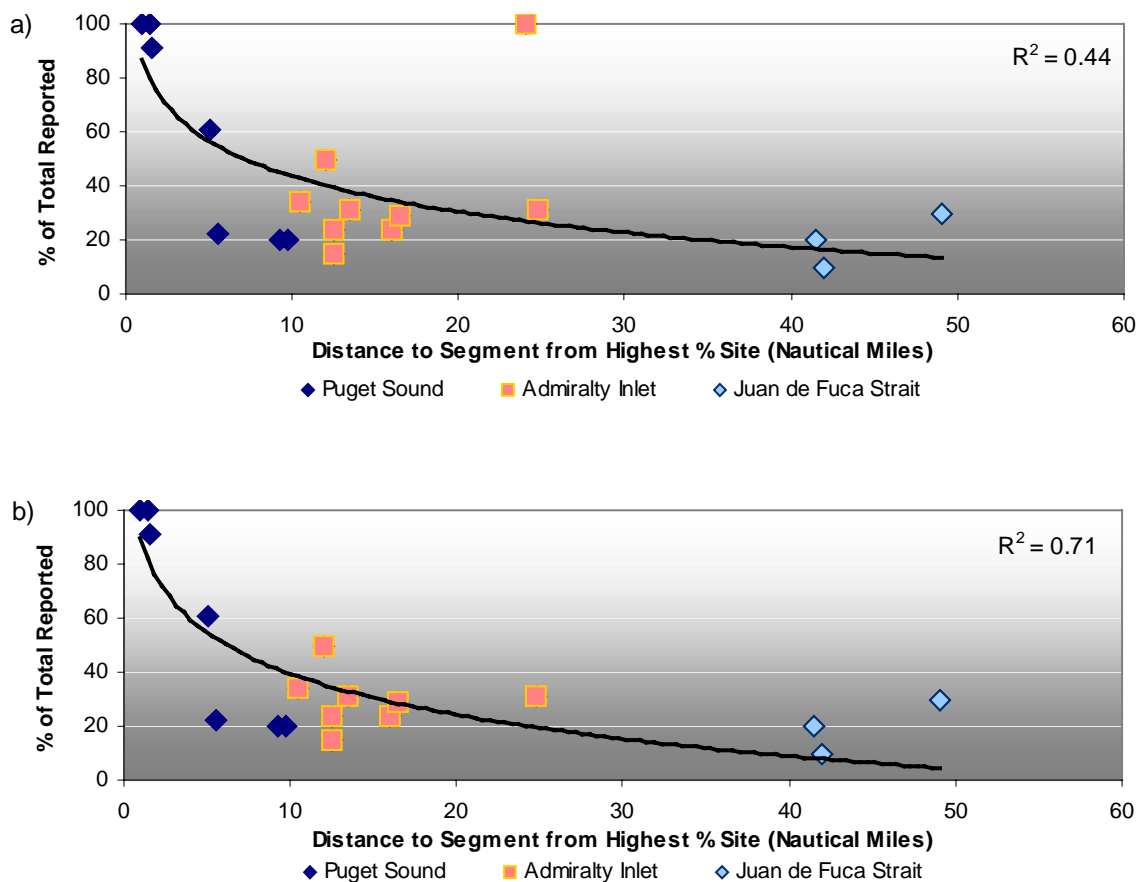


Figure 24 a) The percent of cards reported decreases with distance. The best-fit line is logarithmic. Though the R^2 value is relatively low, a trend can be seen. The out-lying, high-percentage point from Admiralty Inlet was reported from Admiralty Head and originated from Site 4, Release 3, during which high southerly winds quickly swept the cards out through Admiralty Inlet. b) With the out-lying point removed from the data set, the R^2 value increased from 0.44 to 0.71.

Drogues

Results from the August 28 drogue release (1-meter depth) showed that 3 of the 4 inshore drogues (at sites 2, 4, 8) beached on the shores closest to their release sites. The drogue from Site 1 also beached in the same area as that from Site 4, but the remaining drogues all meandered about, then headed toward Admiralty Inlet ([Fig. 25](#)).

Results from the October 25 drogue release, at a depth of 20-30 meters, showed quite different results in that 5 of the 7 drogues (Site 6 drogue malfunctioned) traveled northward into Possession Sound, while currents swept the other two drogues out to Admiralty Inlet (from Site 3) and up to Edmonds (from Site 8) ([Fig. 26](#)).

Discussion

Three questions were raised in this study: (1) Why were so few cards found in the Main Basin? (2) Is there a difference in the percent recoveries between inshore and offshore release sites? (3) What caused differences in the drogue behavior between the sites? These questions are addressed below.

Comparison of Drogue, Drift Card and ADCP data

Why were so few cards found in the Main Basin? Of the 564 cards reported, only 22% (123 cards) were found in the Triple Junction, 71% (87 cards) of which were found on the shores closest to the release sites. A previous drift card study in Elliott Bay showed that percentage recoveries decreased with distance offshore (Ebbesmeyer and others 1998b). To examine this aspect, the percentage of cards found from inshore release locations were compared with those found from offshore releases ([Fig. 9](#)), and the percent of total cards reported from the six above-mentioned selected sites were plotted against the distance to those regions from the release site that supplied the highest percent of cards ([Fig. 24](#)).

The inshore release sites were located on the 70-meter isobath, which were located approximately half a mile from land. Of the 123 cards found in the Main Basin, 85% (104 cards) were from inshore sites. Additionally, 85% (89 cards) of the 104 were found on the shores closest to the release sites, and two of the four near-shore sites (sites 4 and 8) accounted for the near-shore recoveries. Cards from sites 2 and 6 accumulated in and north of Admiralty Inlet, with a few exceptions on the southern tip of Whidbey Island from Site 2, and fourteen on the shores of Indianola from Site 6.

The offshore release sites were located a mile farther offshore than their counterparts. Only 19 cards were found in the Triple Junction that originated from offshore sites, which account for only 15% of the 123 cards found in this region. This amounts a 70% decrease in percentage recoveries from inshore to offshore release locations. In agreement with previous studies, these percentages suggested that distance from shore is an important factor in the percentage return. This further suggests substantial flushing of surface water from the Triple Junction.

Why is there a substantial difference between inshore and offshore recoveries? To examine this, the results from the drogue studies were compared to those of the drift cards. In this comparison, it was found that the drift card recovery locations were a fair representation of the drogue tracks. Exceptions were the October 25 drogues that traveled up into Possession Sound ([Fig. 26](#)). Representative of drift card results, three of the four near-shore surface drogues deployed on August 28 beached on shores close to their deployment sites (from sites 2, 4 and 8). In contrast, the drogue from Site 6 traveled in the direction of the Triple Junction, similar to the behavior of the drogues released from offshore sites. To examine this discrepancy, the net flow patterns of the Puget Sound were compared to the drift card and drogue tracks.

[Figure 1](#) shows the general net circulation of the Puget Sound derived from historical data, results from the King County Puget Sound Numerical Model, and unpublished results from an ongoing survey of the circulation in Puget Sound using ADCPs. A core of higher net velocity flow meanders through the Puget Sound, traveling northward and out Admiralty Inlet, with zones of divergence along the way that form areas of back flow (Baker 1984; Cannon 1983; Ziegweid 1999; Matsuura and Cannon 1997; King CO

model; Ebbesmeyer and others 2001, unpublished work). Drift card recovery locations and drogue tracks overlaid on the net flow patterns generally coincide. Inside Puget Sound (as defined in [Fig. 2](#)), there were four major collection zones: Meadow Point, Indianola, Edmonds and Point no Point. Beyond the Triple Junction, there were five major collection zones: Double Bluff and Mutiny Bay, Marrowstone Island, Admiralty Head, Port Townsend and Dungeness Spit.

Considering the net flow patterns, it appears that the recoveries at Meadow Point and Indianola result from two back eddies that form as a result of the divergence at (B) in [Figure 1](#). All of the cards found at Indianola, and the majority of the cards found at Meadow Point were from the second release, with Indianola as a collection zone for cards from sites 5 and 6, and Meadow Point a collection zone for cards from sites 7 and 8. At both locations, the majority of the cards came from the inshore sites. Because sites 5 and 6 are north of Indianola, their discovery at Indianola seemed to be anomalous; however, because the tides were switching to a flood tide toward the end of this deployment, it is possible that the cards from these sites as well as those from sites 7 and 8 were swept southward into the back flow eddy at (E) or (C) in [Figure 1](#). After moving southward, cards from sites 5 and 6 eventually made their way to Indianola, as it has been shown that flow separation and the formation of tidal eddies provide a transport mechanism for offshore water to reach the shoreline (Signell and Geyer 1991). The amount of time that it took for these cards to be reported from this site (some within two weeks, but the majority within 1-3 months) supports this idea. The August 28th drogue from Site 5 supports this possibility as well, as it followed a similar path as that described above ([Fig. 1](#)). Cards from sites 7 and 8 appeared to be caught up in the back flow eddy at (E), with many cards from Site 8 heading directly to the nearby shore, along with a few from Site 7, though most cards from Site 7 continued northward and into Admiralty Inlet. The August 28 drogues from sites 7 and 8 support this hypothesis, as the Site 8 drogue beached at Meadow Point, and that from Site 7 followed the path of the eddy, then headed northward, following the path of the higher-velocity core ([Fig. 25](#)).

The majority of the cards found on the shores of Edmonds were from sites 3 and 4, and appear to represent the divergence at (G) ([Fig. 1](#)). The other cards from these sites were primarily found in the vicinity of Admiralty Inlet, following the path of the higher-velocity core. Drogue track results followed similar paths. The August 28 drogue from Site 4 beached just south of its release site, and both the August 28 and October 25 drogues from Site 3 headed in the direction of Admiralty Inlet following the path of the core.

In agreement with the net flow pattern shown in [Figure 1](#), Point No Point collected cards mostly from offshore locations. This can be seen as the high-velocity core flows past the southern release sites, picking up cards via back flow eddy circulation, and joins with flow from the northern release sites.

Beyond Puget Sound, the drift cards accumulated on headlands and spits, though the regions of emphasis varied between the two, emphasizing the importance of local winds and tides. Additionally, there seemed to be a relationship between the percent breakdown of the cards that were found at a location and the distance to each of the release sites. Collection zones within the Triple Junction showed preferential behavior toward certain sites, decreasing with distance from the release sites ([Figs. 18-23, 24](#)). Therefore, the farther the collection zone is from the release sites, the greater the variability in the cards found at that location. That is, the cards tend to 'forget' the site from which they originated.

Another question is whether or not drift card results are characteristic of the shallowest meter of water, or if they are more representative of a thin surface microlayer. In this study, drift card recovery locations for all three releases showed reasonable similarity to the drogue tracks both at the 1-meter and 20-meter depths (D and E, respectively). Additionally, the drift card collection zones seem to reflect the 20-meter drogue tracks as well as the net surface flow.

Acknowledgements

The authors would like to thank the beachcombers for reporting the drift cards, the staff at Evans-Hamilton, Inc. and King County Department of Natural Resources for assisting with card deployment, Brent Johnston (EHI) for preparing the figures and Glenn Cannon for his helpful input. This work was performed under the Evans-Hamilton, Inc. contract with the King County Department of Natural Resources.

References

- Baker, E.T. 1984. Patterns of suspended particle distributions and transport in a large fjord like estuary. *J.Geophys.Res.*, 89, 6553-6566.
- Cannon, G.A. 2000b. Wind effects on circulation in Puget Sound. Presented at Pacific Estuarine Research Society Meeting 1998, in preparation.
- Cannon, G.A. 1983. An overview of circulation in the Puget Sound estuarine system. NOAA Technical Memorandum ERL PMEL-48, 30 pp.
- Ebbesmeyer, C.C. and Coomes, C.A. 1993. Historical shoreline recoveries of drifting objects: an aid for future shoreline utilization. *Oceans '93*, Oceanic Engineering Society, Institute of Electrical and Electronics Engineers, Inc., Proceedings, Vol. III, pp. 159-164.
- Ebbesmeyer, C.C., Coomes, C.A., and Noah, E.C. 1995. Winter dispersion and intrusion of floating wooden cards released along Juan de Fuca Strait. *Puget Sound Research '95 Proceedings*. Vol. 2, pp. 971-978. Puget Sound Water Quality Authority, Olympia, WA.
- Ebbesmeyer, C.C., Stewart, R.J., and Albertson, S. 1998a. Circulation in southern Puget Sound's finger inlets: Hammersley, Totten, Budd, Eld and Case Inlets. *Proceedings of the Puget Sound Research Conference held 12-13 March 1998 in Seattle*. Puget Sound Water Quality Action Team, Olympia, WA.
- Ebbesmeyer, C.C., Shuman, R., Coomes, C.A., Cox, J.M., Crone, T.J., Kurrus, K.A., and Noah, E.C. 1998b. Current structure in Elliott Bay, Washington: 1977-1996. *Proceedings of the Puget Sound Research Conference held 12-13 March 1998 in Seattle*. Puget Sound Water Quality Action Team, Olympia, WA.
- Lavelle, J.W., Cokelet, E.D., and Cannon, G.A. 1991. A model study of density intrusions into and circulation within a deep silled estuary: Puget Sound. *J.Geophys.Res.*, 96, 16779-16800.
- Matsuura, H., and Cannon, G.A. 1997. Wind effects on sub-tidal currents in Puget Sound. *J.Oceanogr.*, 53, 53-66.
- Word, J.Q., Boatman, C.D., Ebbesmeyer, C.C., Finger, R.E., Fischnaller, S., and Stober, Q.J. 1990. Vertical transport of effluent material to the surface of marine waters. *Oceanic Processes in Marine Pollution*. 6:134-149.
- Ziegwied, A.T. 1999. An examination of the mean current profile and circulation patterns throughout a lunar cycle near Point Wells, Puget Sound, WA. B.S. Thesis, School of Oceanography, University of Washington.

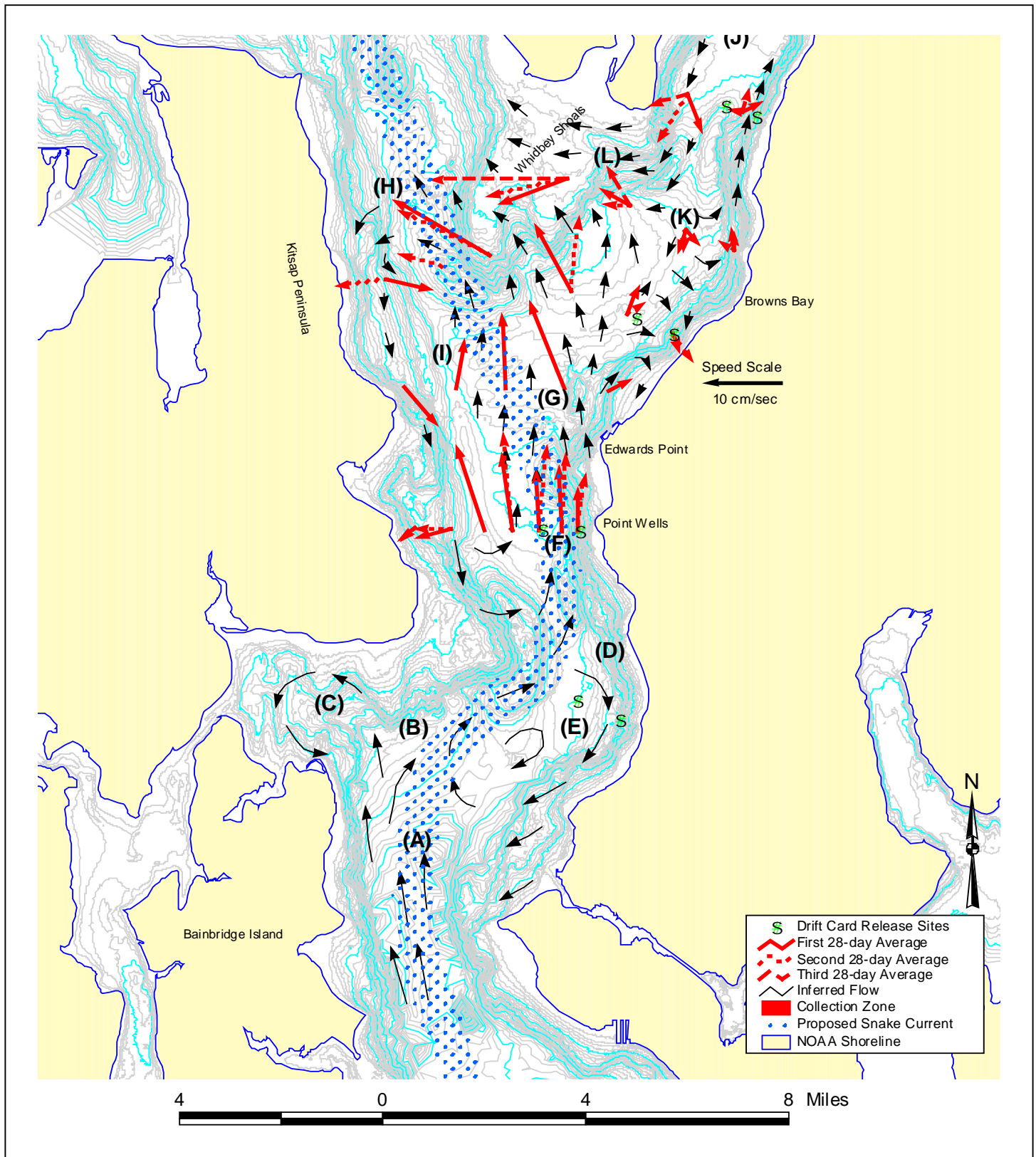


Figure 1. A-B) Originating from the outflow of Colvos Passage, a higher velocity core is thought to continue northward (A) until it comes to the shoals off Point Jefferson (B) where there is evidence that it splits (King County model); C-F) Part is deflected westward, creating a back flow by Indianola (C), and part is deflected eastward toward (D), where part of the flow diverges, creating a back flow toward Meadow Point (E), and the majority of the flow remains northward past Point Wells (F) (Baker, 1984); G-I) flow diverges in the Triple Junction, creating a weak back flow just north of Edwards Point (G) and along the Kitsap Peninsula (H, I), then continues out to Admiralty Inlet; J-M) Flow comes down from Possession Sound (J), and splits at (K), part converging with the Main Basin flow (L), and part diverging toward Browns Bay, creating northward alongshore flow back into Possession Sound (M).

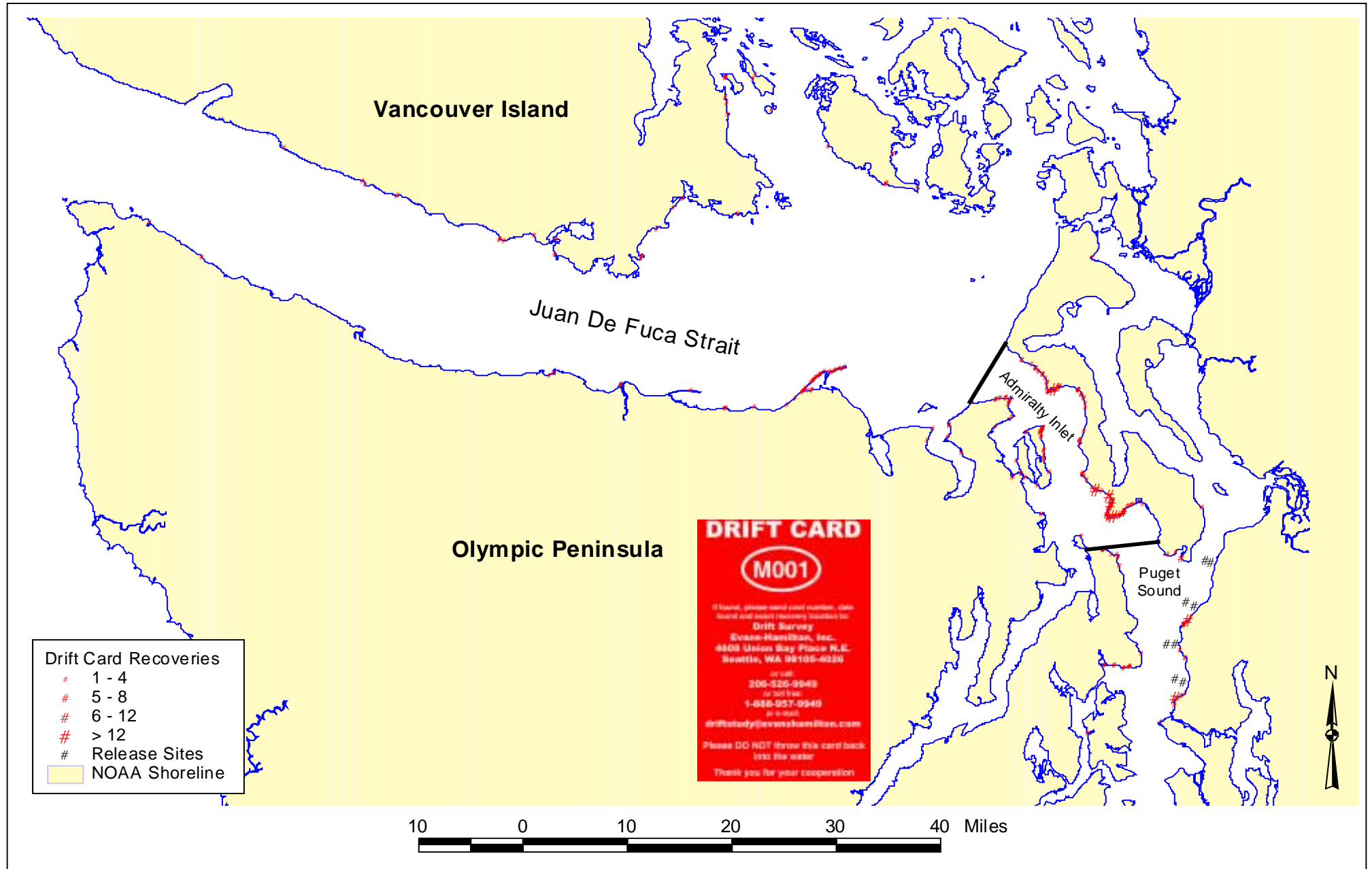


Figure 2 Locations of the drift card release sites and recoveries: all three releases, all sites.

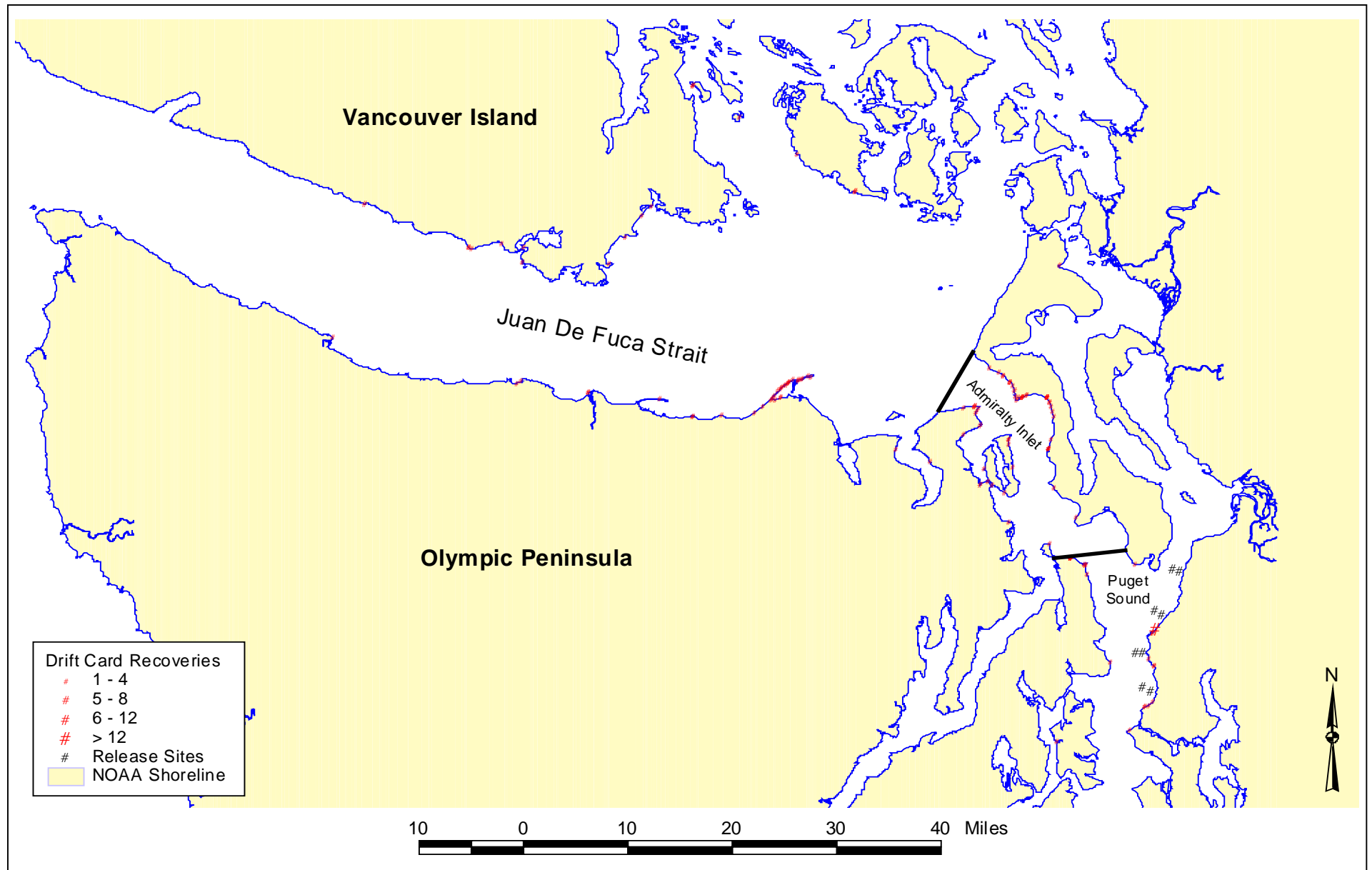


Figure 6 Release 1: August 28, 2000. Locations of the drift card release sites and recoveries for all sites. Cards were released during a strong ebb tide under weak and variable winds.

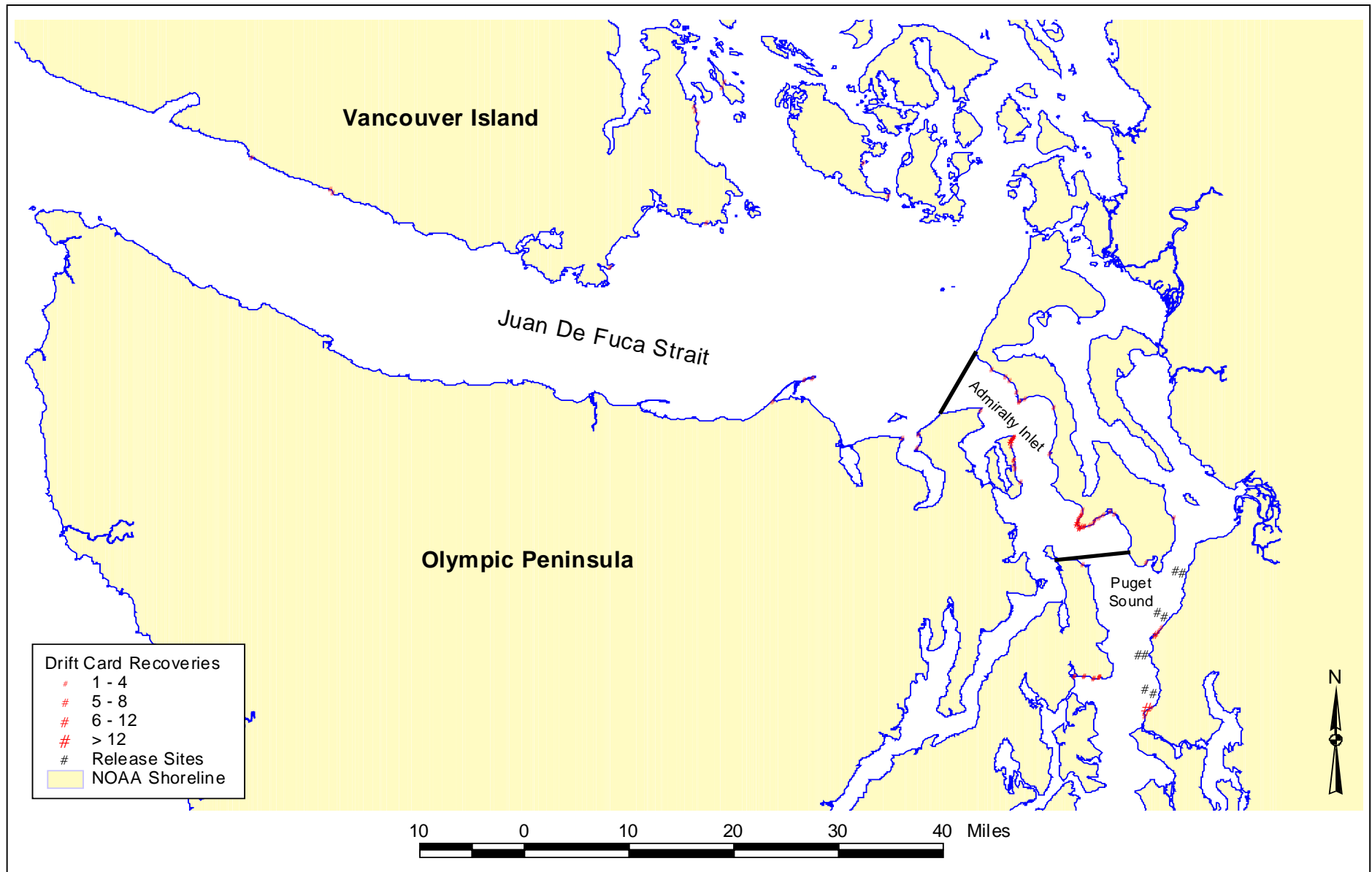


Figure 7 Release 2: October 25, 2000. Locations of the drift card release sites and recoveries for all sites. Cards were released during a strong ebb tide under weak and variable winds.

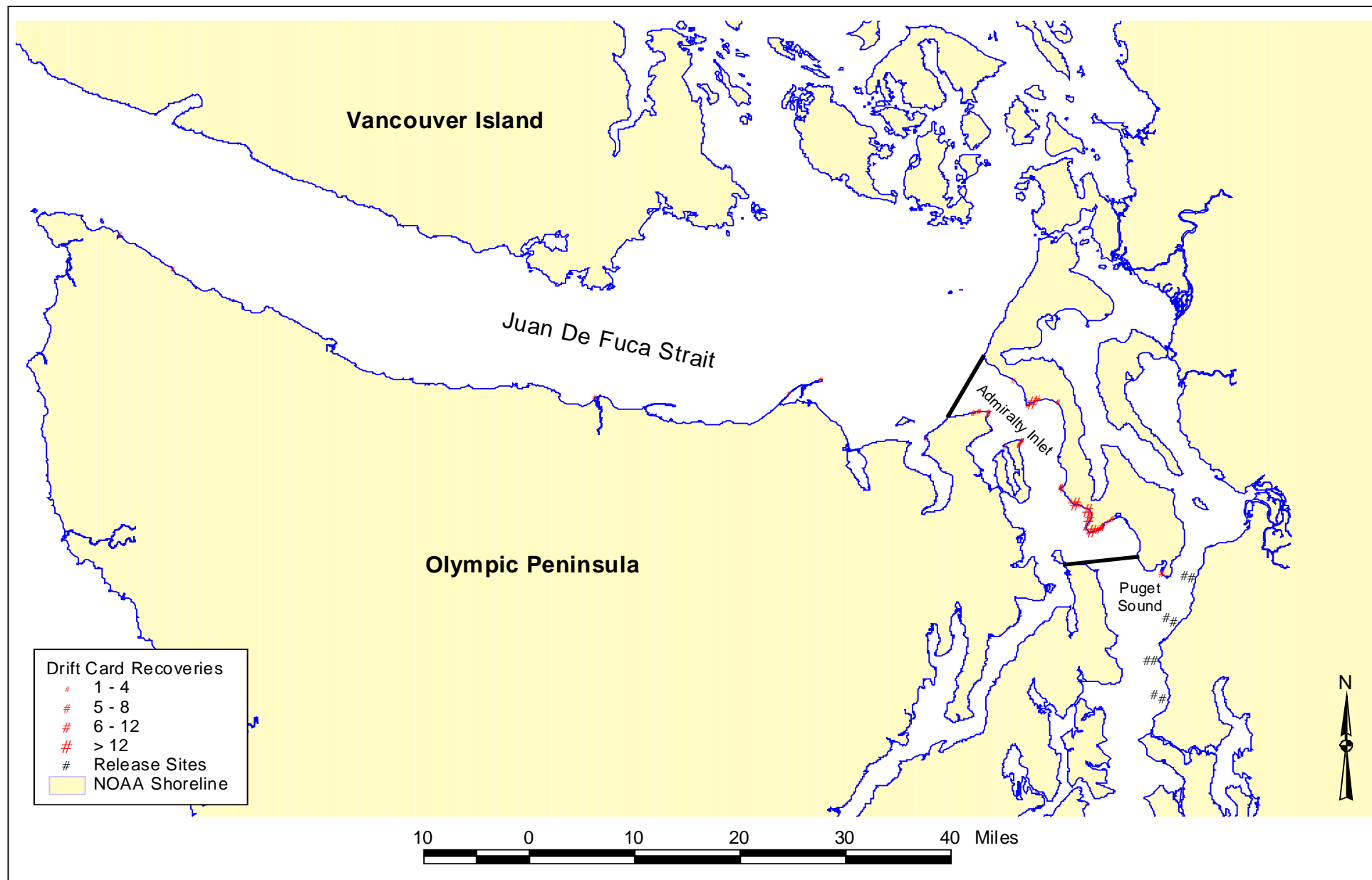


Figure 8 Release 3: November 30, 2000. Locations of the drift card release sites and recoveries for all sites. Cards were released during a strong ebb tide under strong southerly winds.

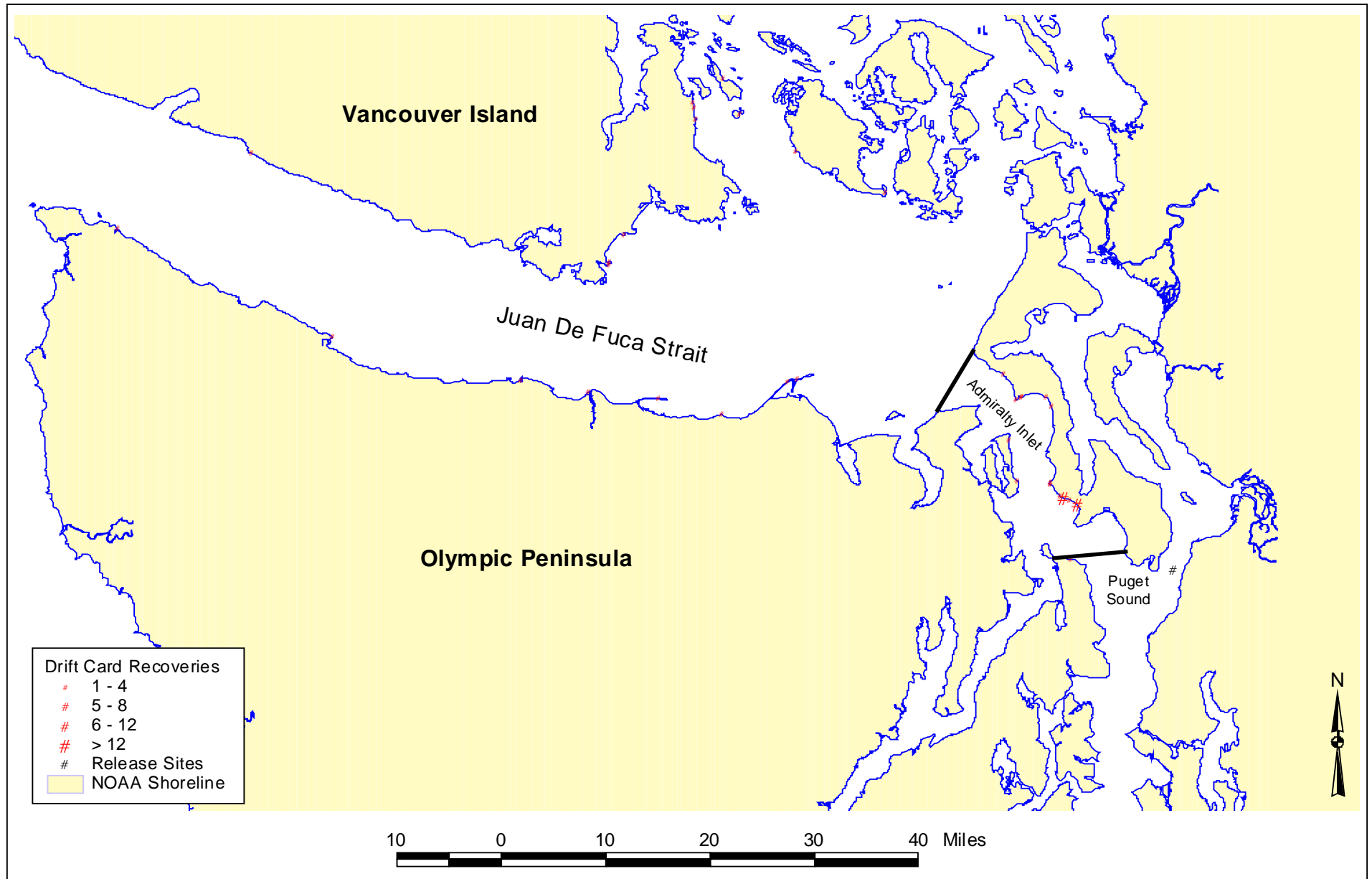


Figure 10 Site 1: Location of drift card release site and recoveries from all releases.

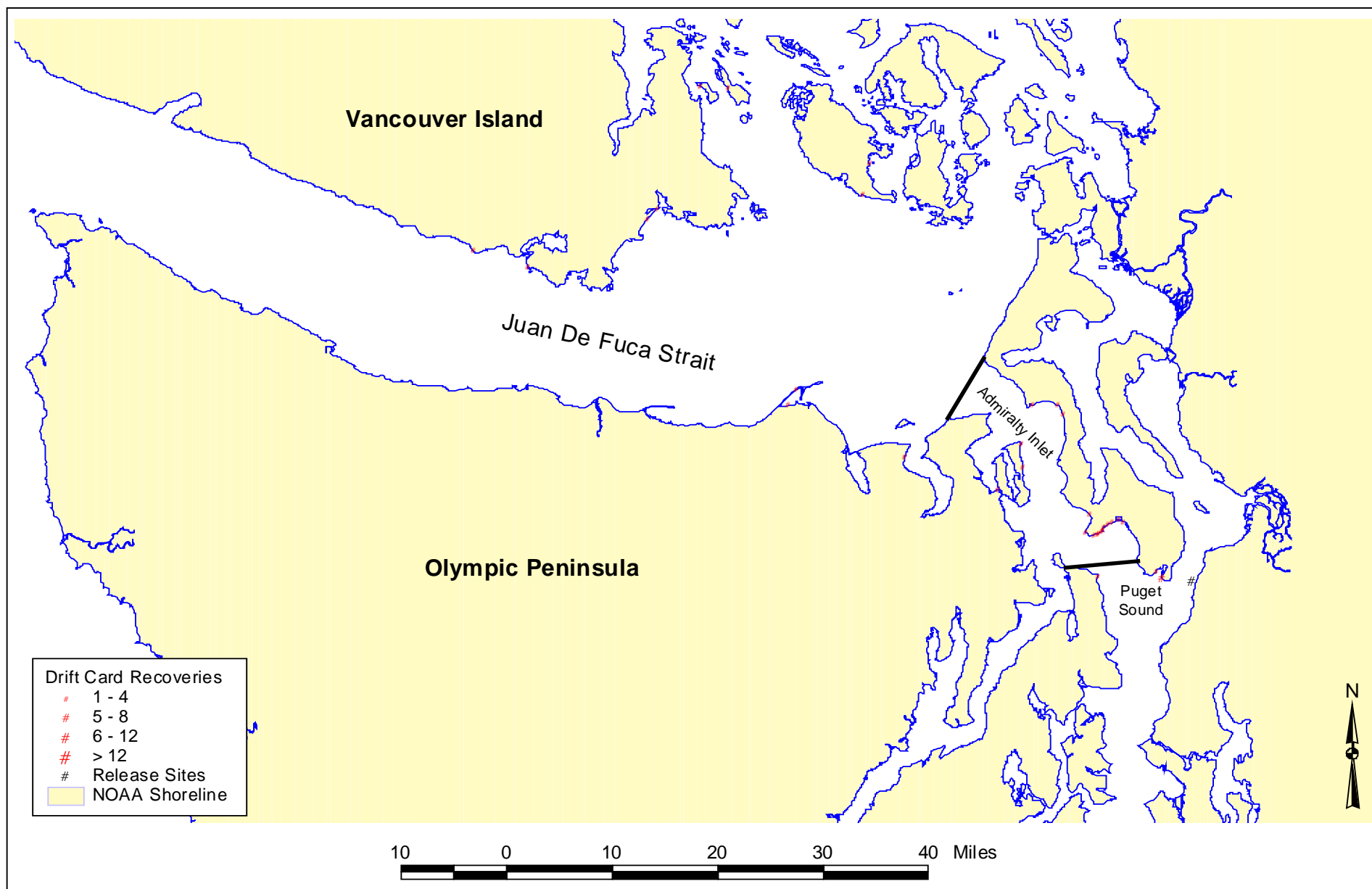


Figure 11 Site 2: Location of drift card release site and recoveries from all releases.

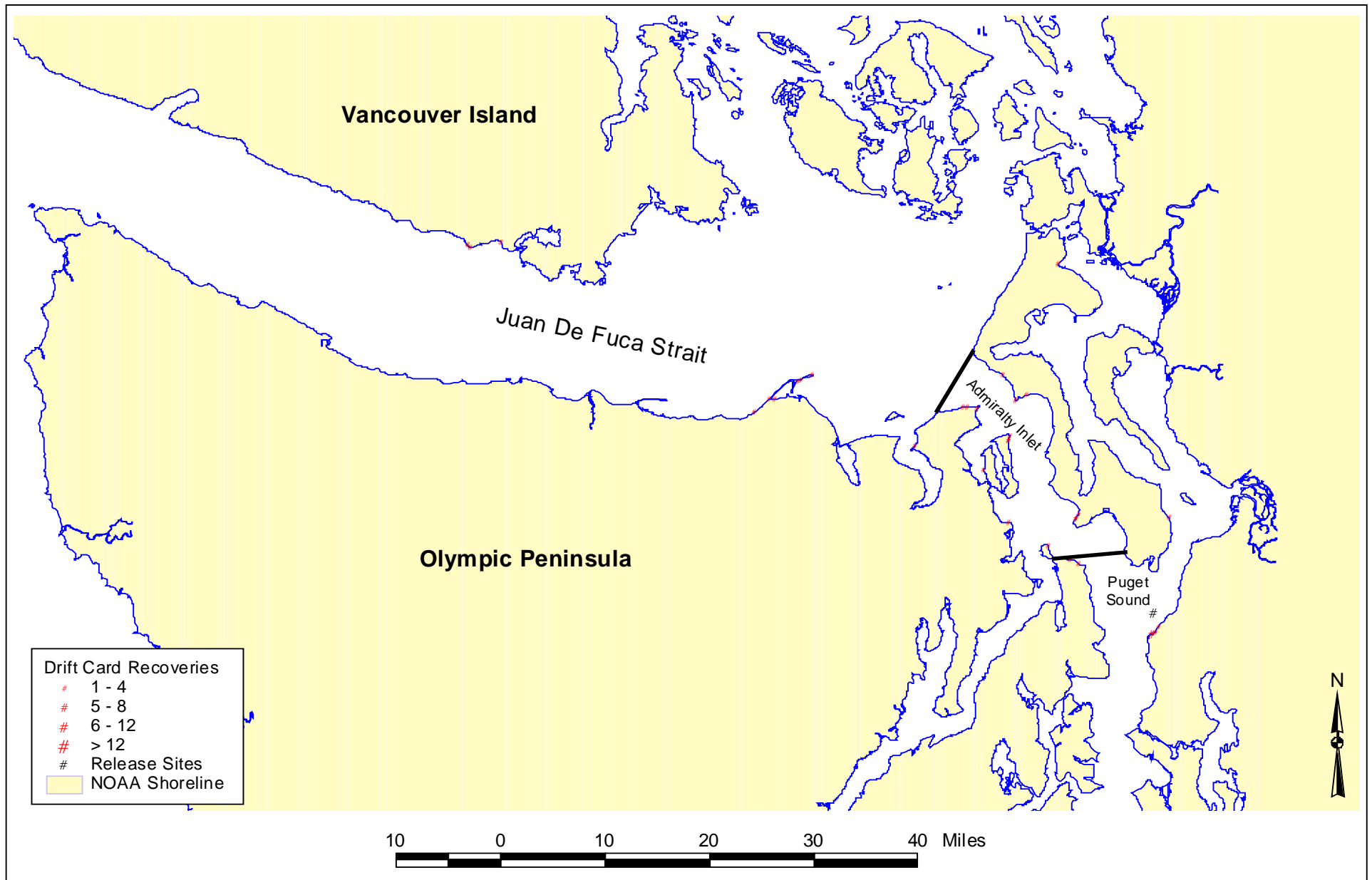


Figure 12. Site 3: Location of drift card release site and recoveries from all releases.

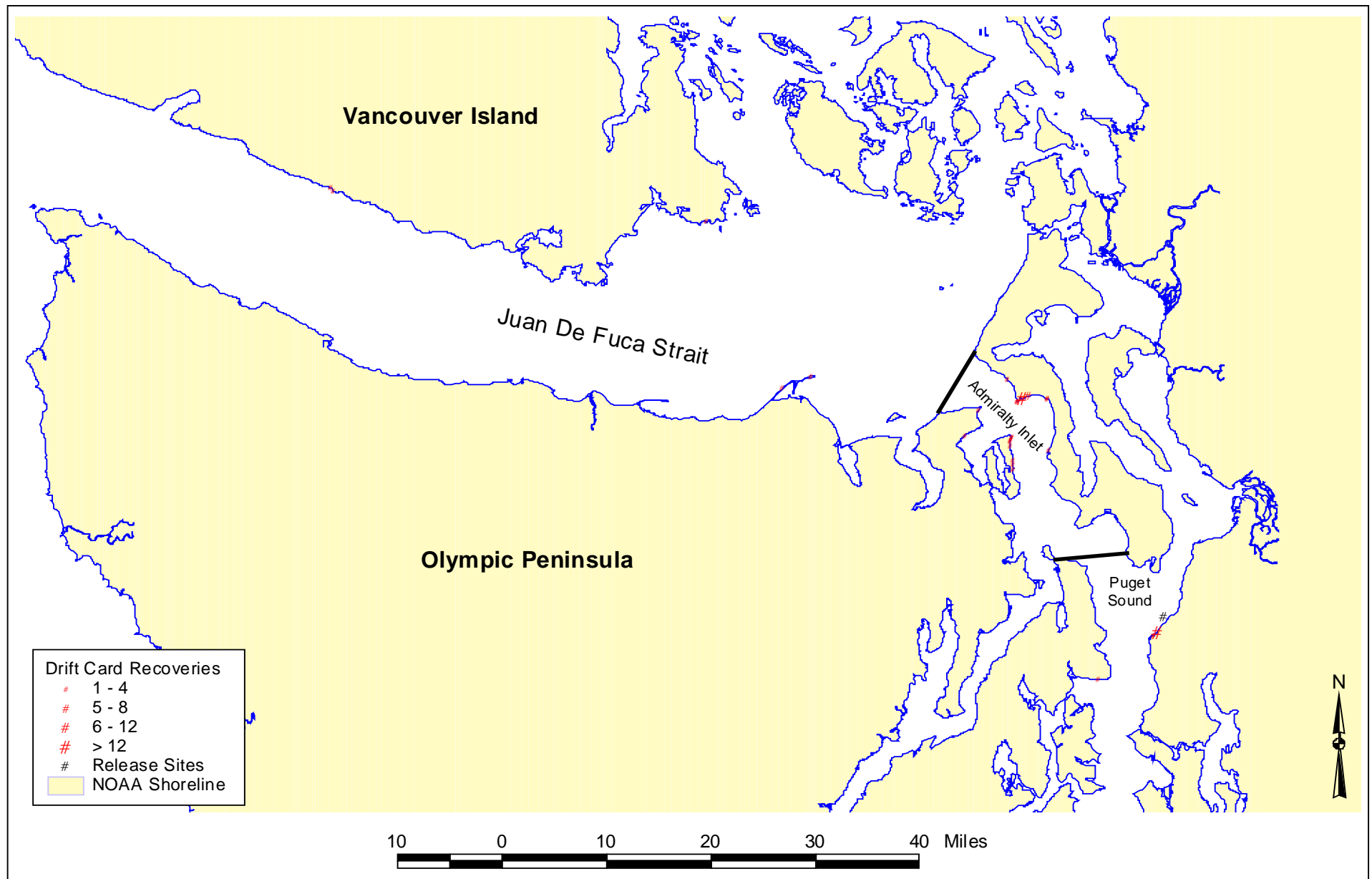


Figure 13 Site 4: Location of drift card release site and recoveries from all releases.

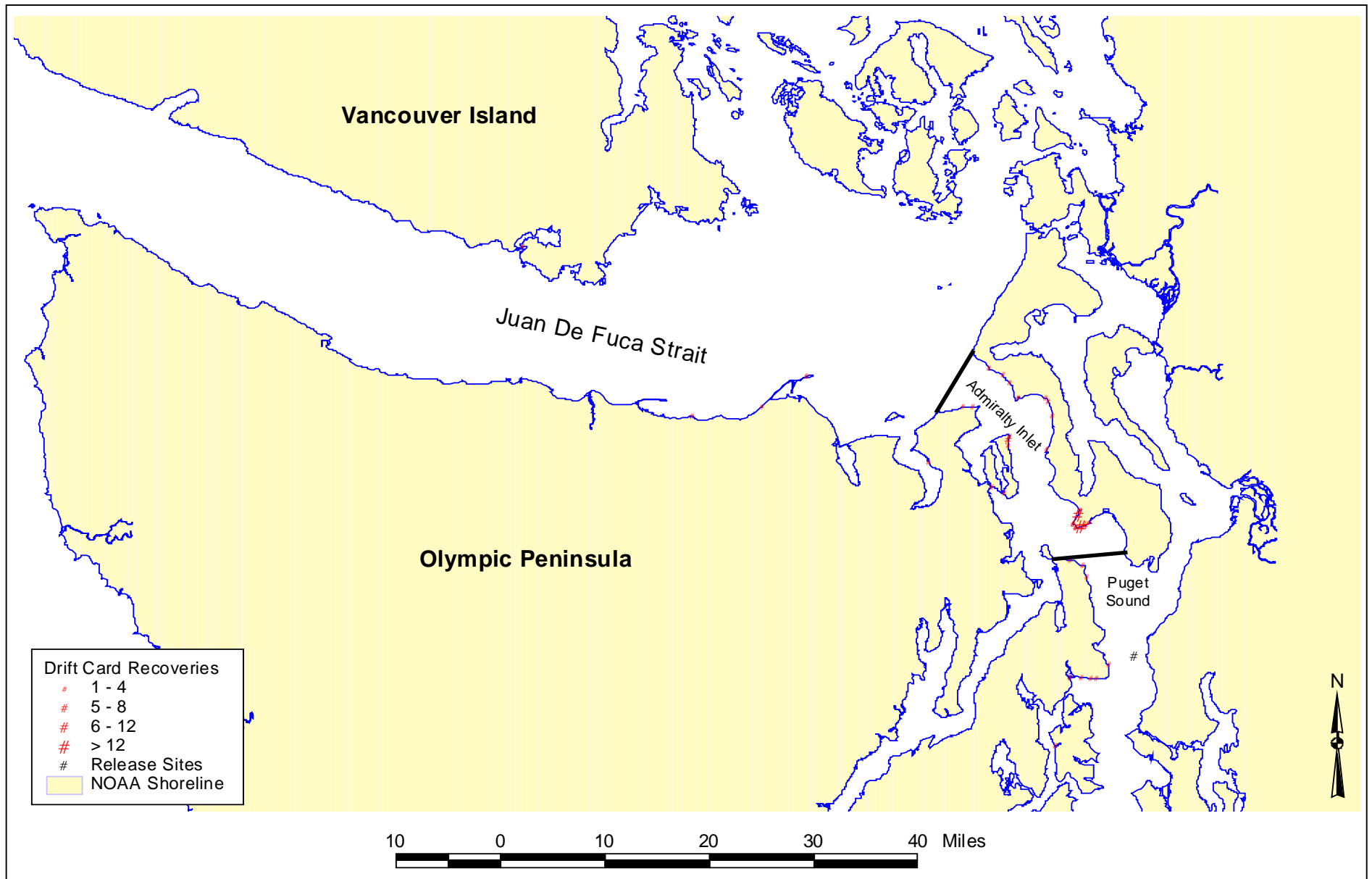


Figure 14 Site 5: Location of drift card release site and recoveries from all releases.

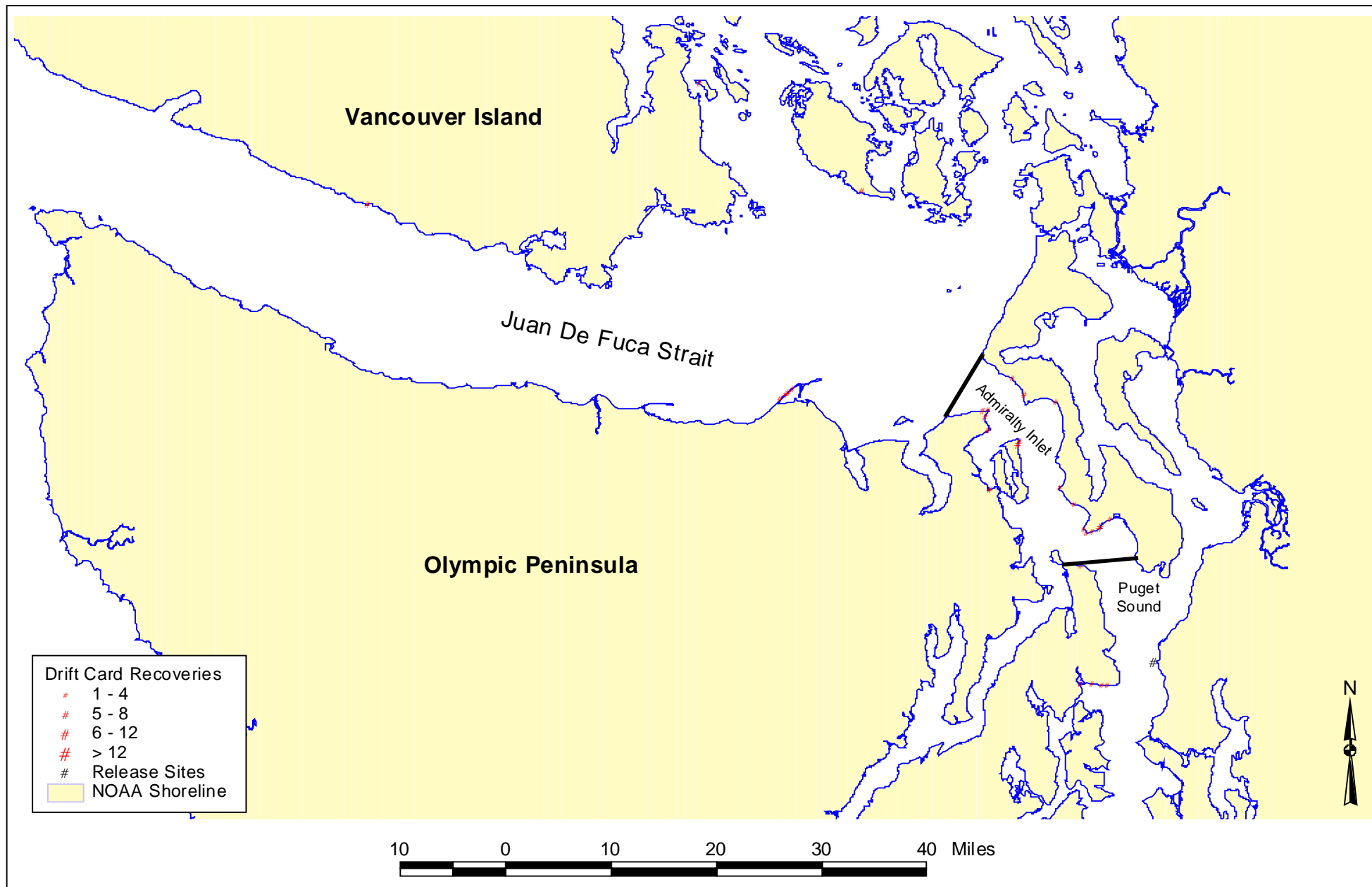


Figure 15 Site 6: Location of drift card release site and recoveries from all releases.

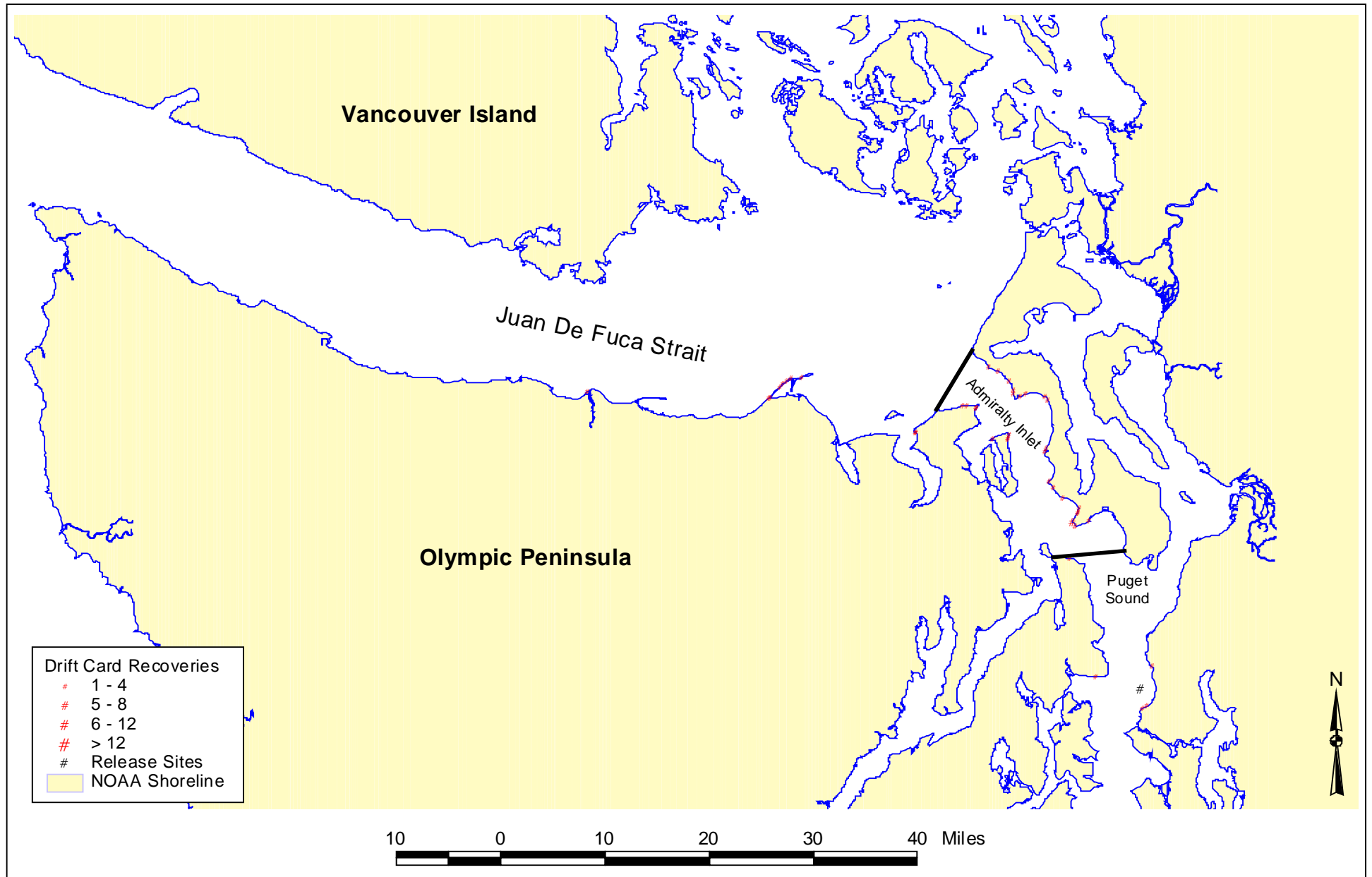


Figure 16 Site 7: Location of drift card release site and recoveries from all releases.

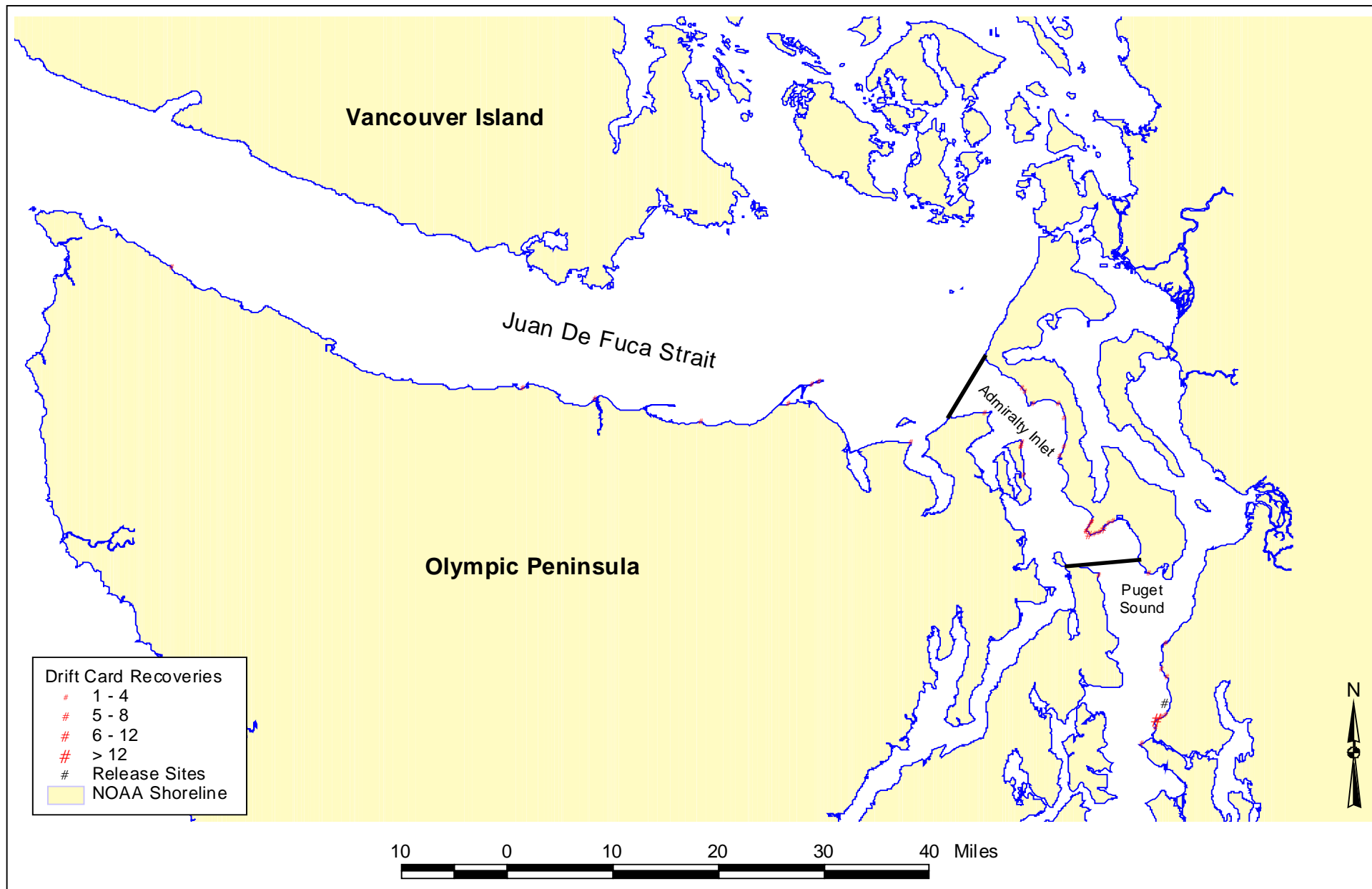


Figure 17 Site 8: Location of drift card release site and recoveries from all releases.

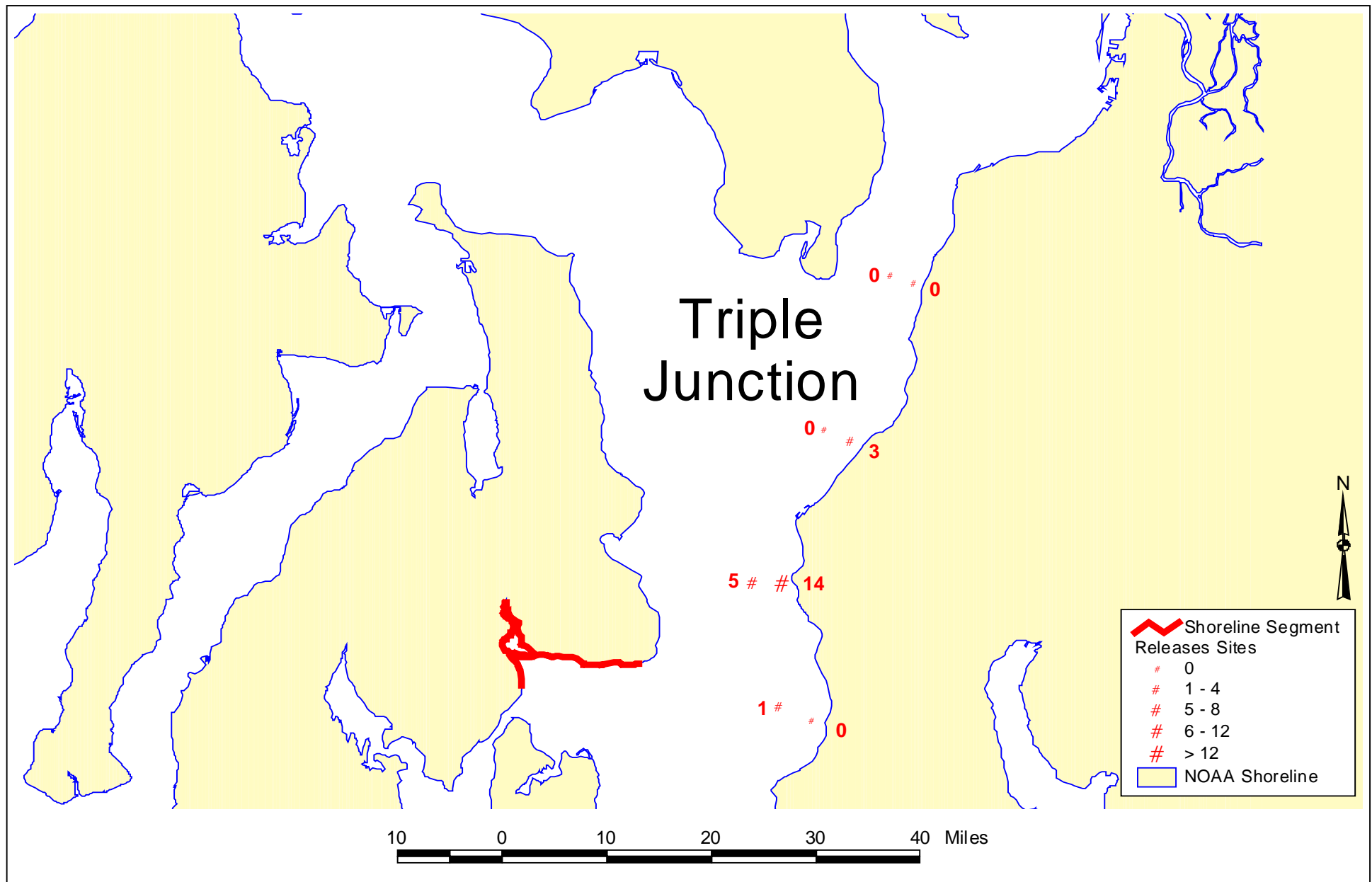


Figure 18 Origins of drift cards arriving near Indianola shoreline segment.

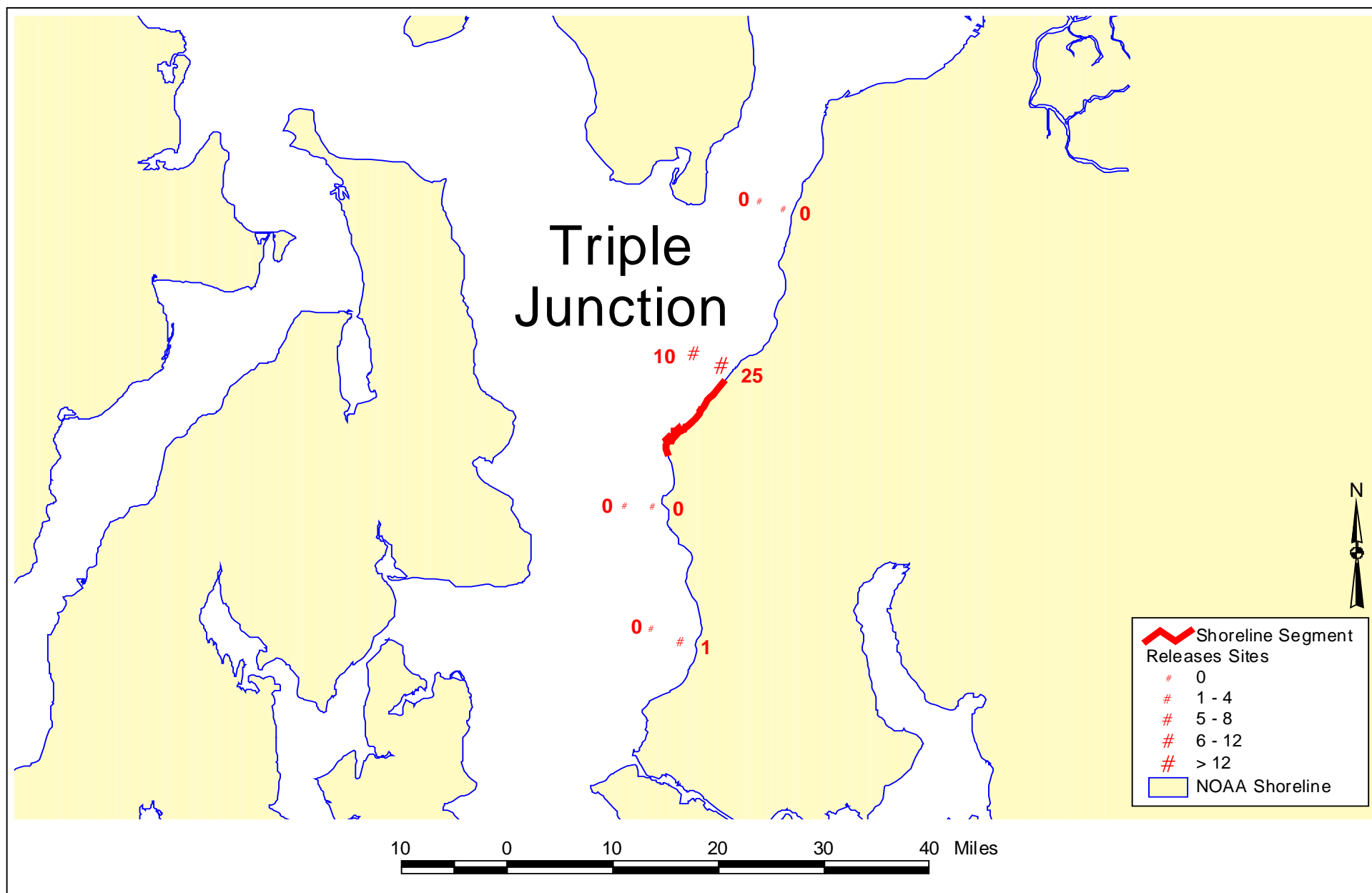


Figure 19 Origins of drift cards arriving near Edwards Point shoreline segment.

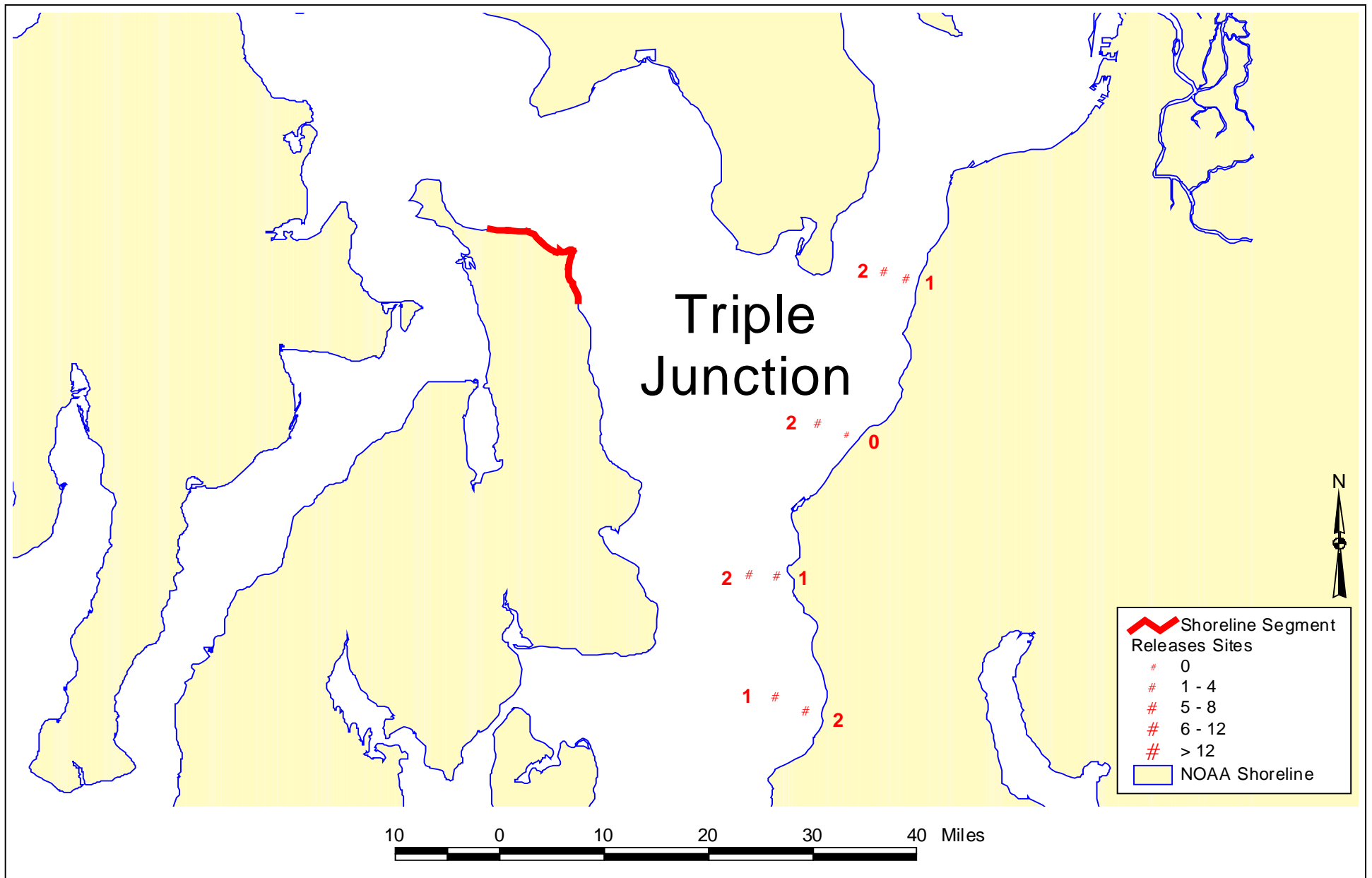


Figure 20 Origins of drift cards arriving near Point No Point shoreline segment.

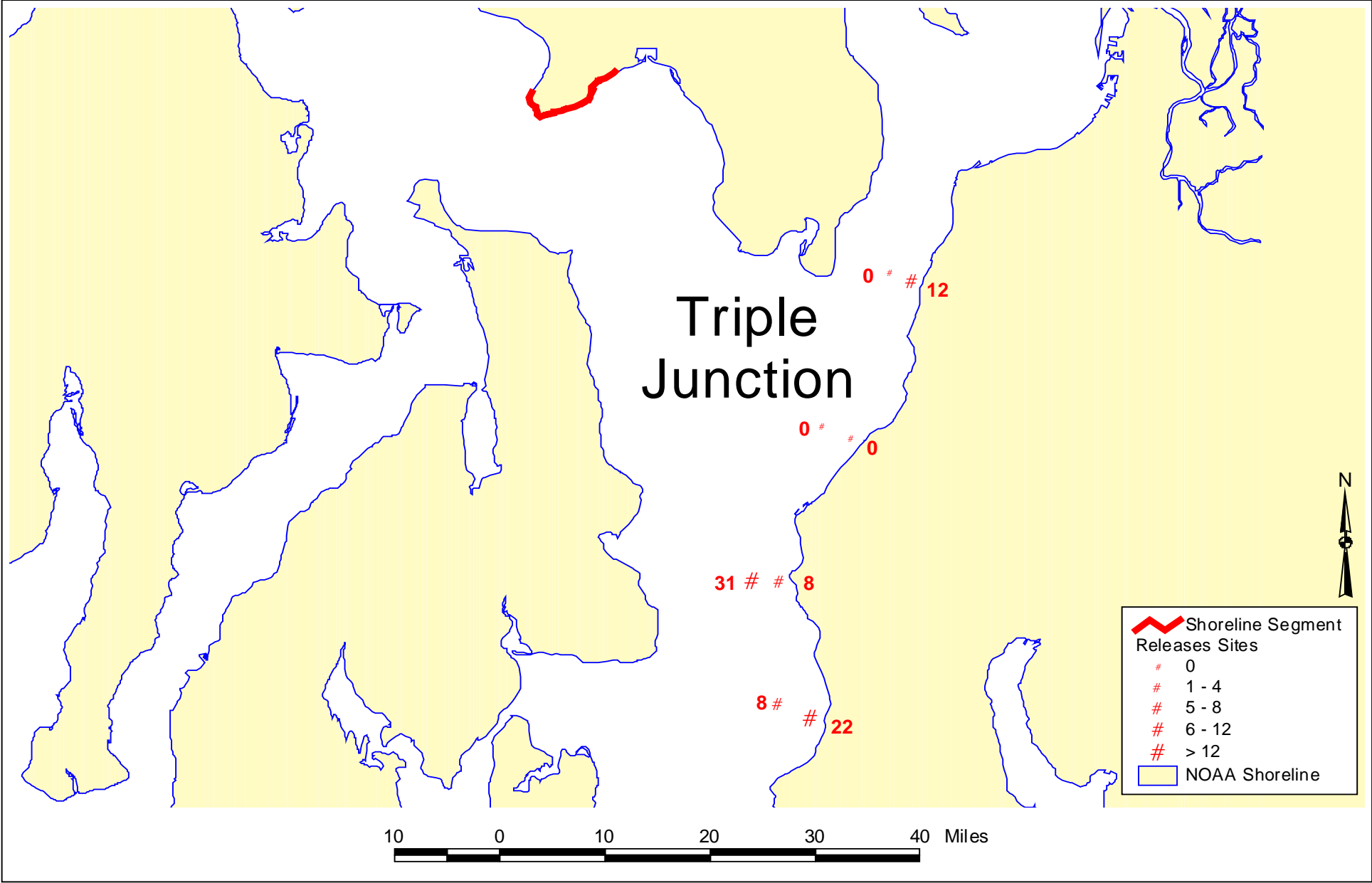


Figure 21 Origins of drift cards arriving near Double Bluff shoreline segment.

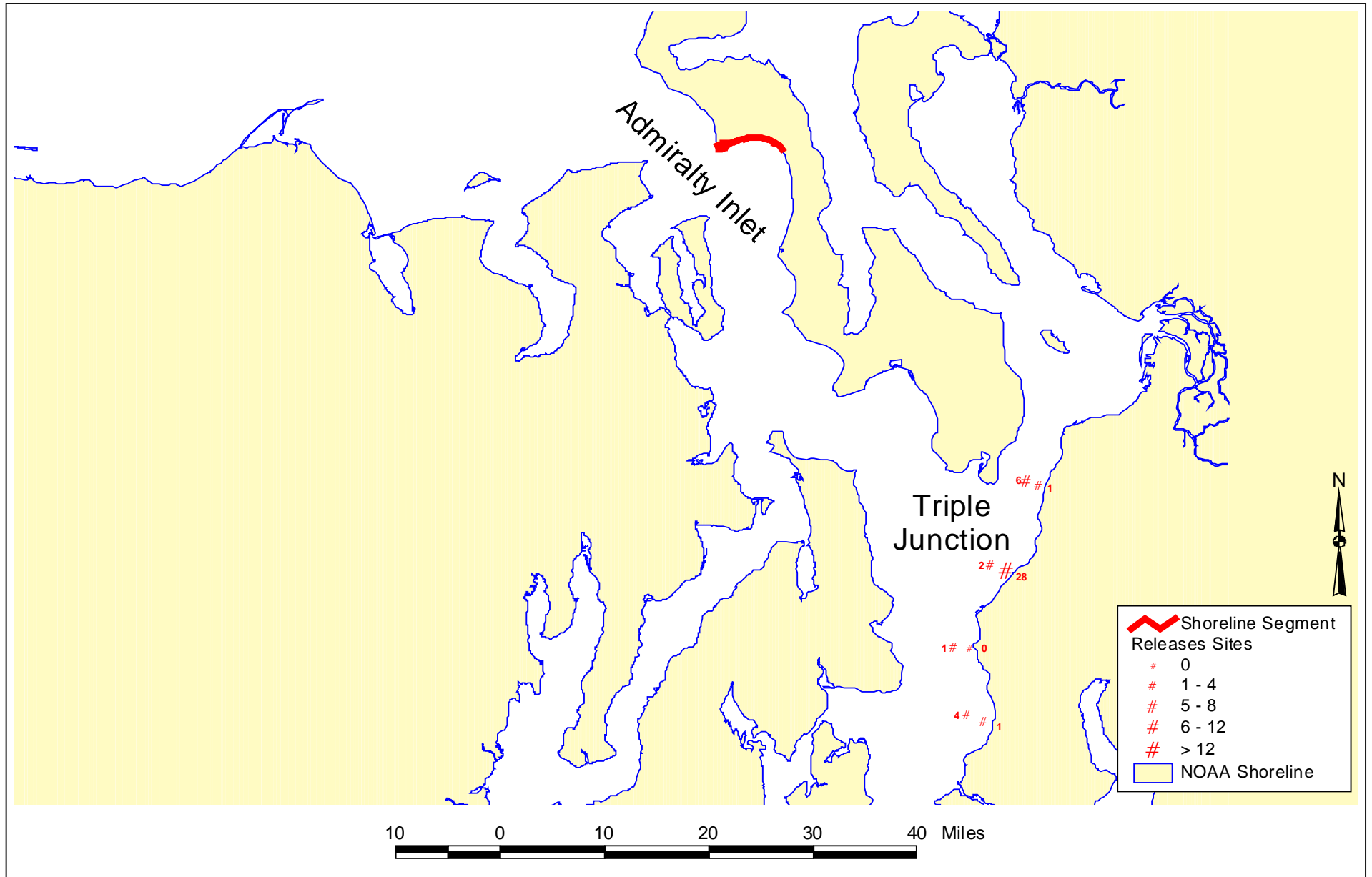


Figure 22 Origins of drift cards arriving near Admiralty Head shoreline segment.

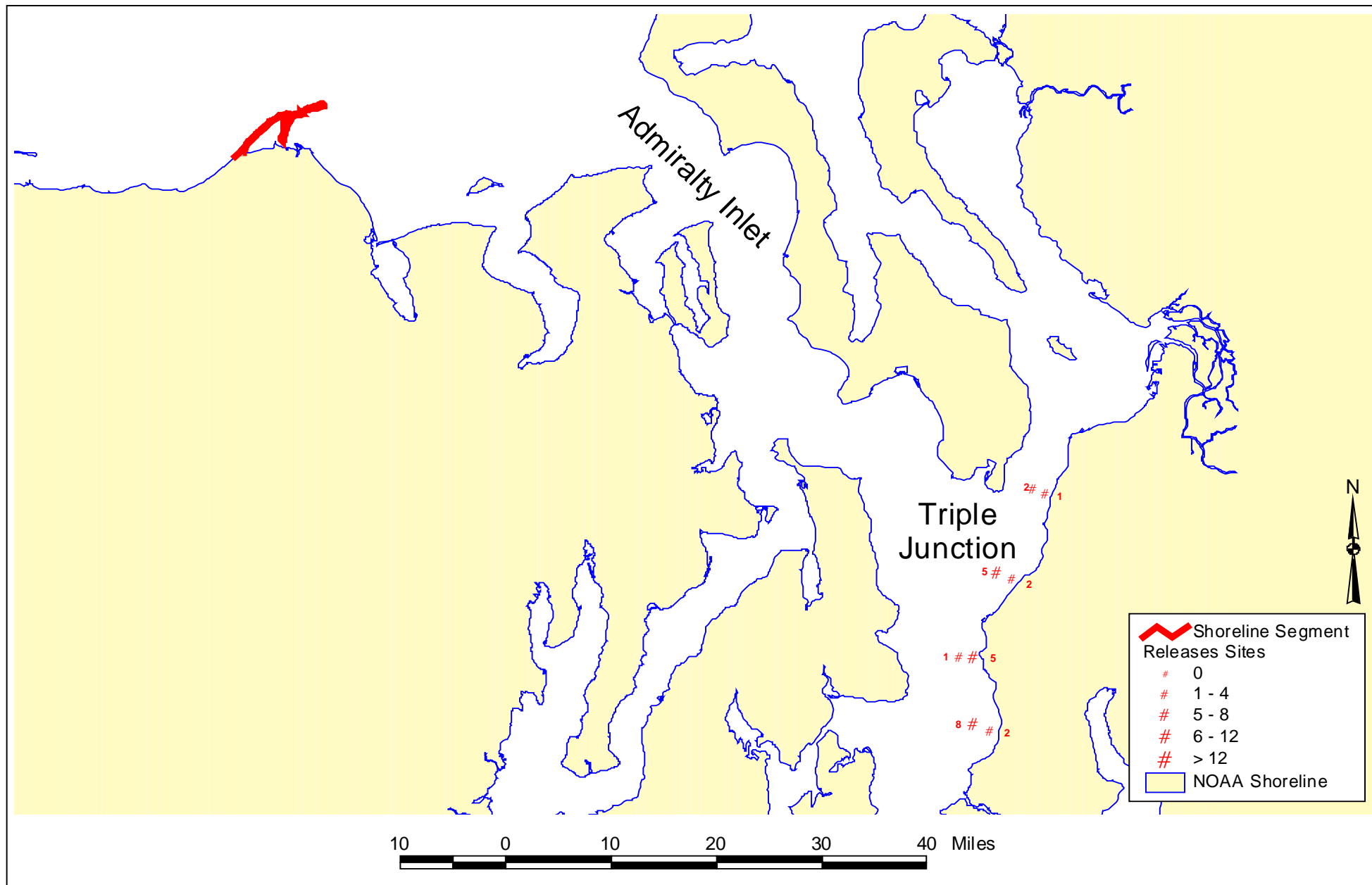


Figure 23 Origins of drift cards arriving near Dungeness Spit shoreline segment.

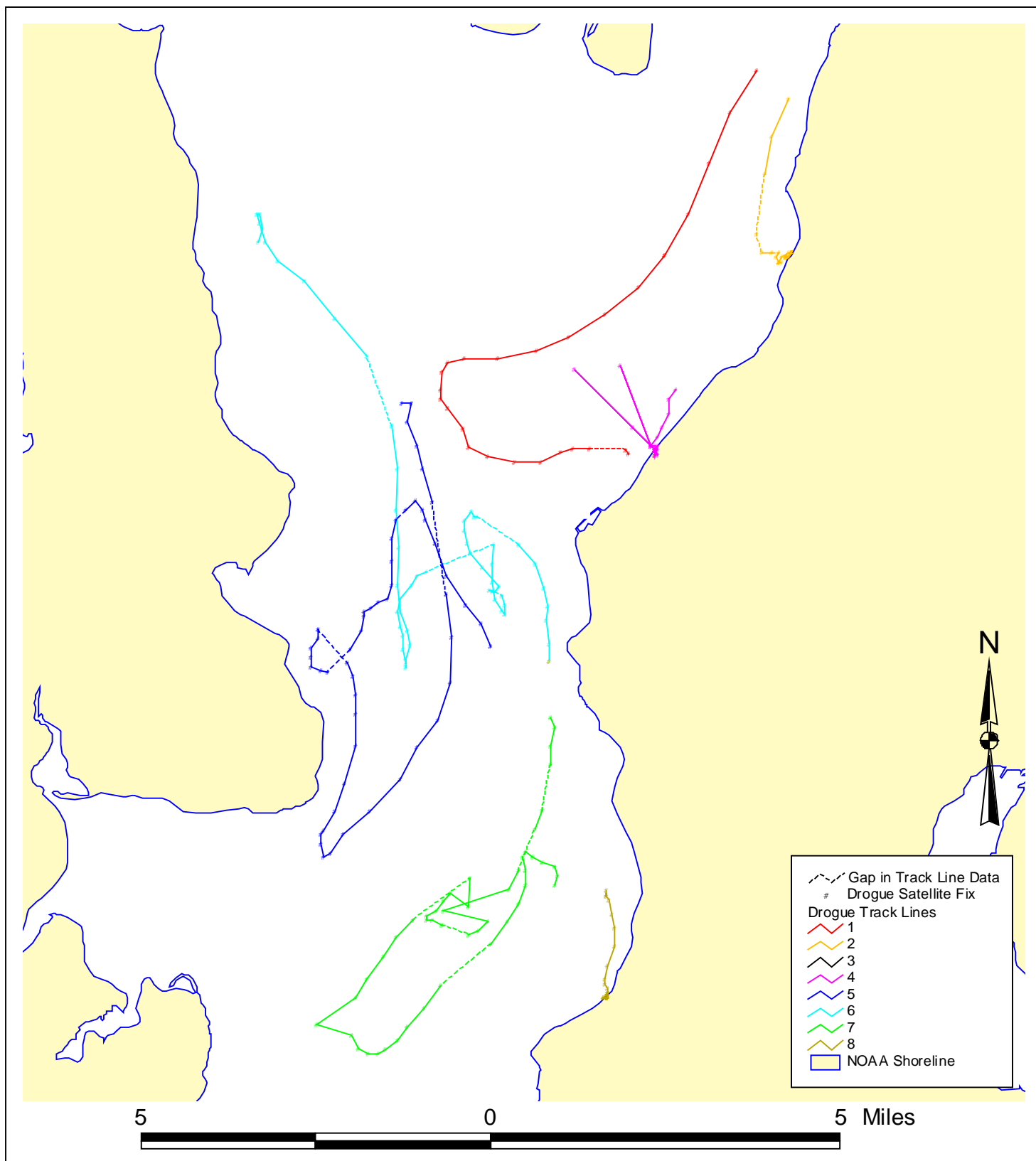


Figure 25 Drogue track lines on August 28, 2000 at one-meter depth.

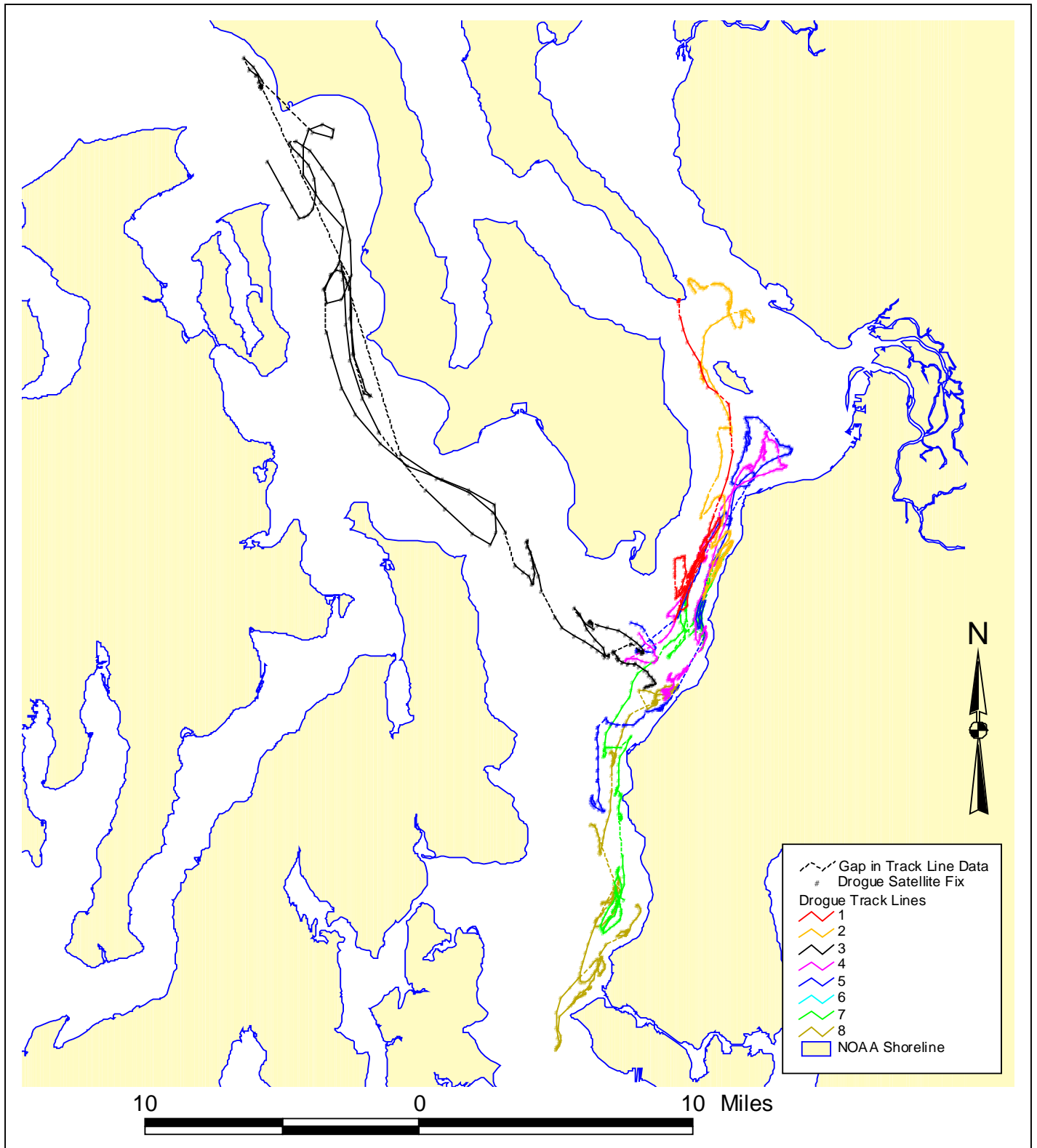


Figure 26. Drogue track lines from October 25 to October 31, 2000 at 20 – 30 meters depth.